CIRRIPEDES FROM THE UPPER CRETACEOUS OF ALABAMA AND MISSISSIPPI, EASTERN GULF REGION, U.S.A.

PART I. PALAEONTOLOGY

By J. S. H. COLLINS

CONTENTS

SYNOPSIS

From the Upper Cretaceous Selma Chalk and Ripley Formation of Mississippi and Selma Chalk of Alabama, U.S.A. valves of nine new species and one new subspecies of cirripedes are described and figured: *Cretiscalpellum harnedi, C. macrum, C. vallum, C. venustum, Arcoscalpellum bakeri, A. campus, A. hubrichti, A. withersi, Brachylepas angulosa, Virgiscalpellum gabbi apertus.* Further valves belonging to *Virgiscalpellum gabbi* (Pilsbry) and two other *Virgiscalpellum* valves are described and figured from the Ripley Formation. They occur in silty, finely sandy and highly foraminiferal and ostracodal horizons within the 'Selma' which represents an 'outer neritic' environment of the continental shelf. Three biostratigraphic horizons are recognized: (1) zone of *Virgiscalpellum* of Ripley and basal Prairie Bluff (Maastrichtian) age; (2) zone of *Cretiscalpellum vallum* of basal Annona or upper Coffee (Campanian) age; and (3) zone of *Arcoscalpellum hubrichti* of middle Mooreville (Santonian) age. These three zones supplement known faunal zones within the Upper Cretaceous.

INTRODUCTION

Between 1935 and 1938 F. F. Mellen corresponded with T. H. Withers of the British Museum (Natural History) and sent numerous small collections of cirripede valves to him for study and for description in a paper Withers had planned. The new forms recognized were received too late for inclusion in the monographic *Catalogue of Fossil Cirripedia*, Vol. 2, *Cretaceous*, 1935. The holotypes were to be retained in the British Museum (N.H.) and paratypes were to be returned to the Department of Geology and Geography at Mississippi State University.

The intervention of World War II, the retirement of Withers and his death in 1958, prevented the completion of the study of the Mississippi barnacle collections which, according to present tabulation, numbered 146 valves from seven localities (see below).

Between 1967–1969 many valves were secured from previous collections and additional hundreds were collected by F. F. Mellen and others, not only from those of the earlier sites that still existed, but from new localities scattered over several Counties in Alabama and Mississippi. A further group of 36 valves, from Greene County, Alabama, were lent to J. S. H. Collins by the Paleontological Research Institute, Ithaca, New York.

HISTORICAL REVIEW

The present material contains only one, *Virgiscalpellum gabbi* (Pilsbry), of the eight species of cirripedes previously recorded from the Cretaceous of the United States of America. Of the other seven species, the generic position of one, '*Scalpellum*' *inaequiplicatum* Shumard 1862, from the Upper Senonian of Texas, was considered by both Shumard and Withers (1935) as provisional, owing to the poor preservation of the specimen. The inadequate description of *Scalpellum* sp. listed by Adkins 1928, from the Upper Austin Chalk of Texas, was also considered to be equivocal by Withers (1935). Of the remaining species, *Loriculina ?texanum* Withers is recorded from the Middle Albian of Texas; *Calantica* (*Titanolepas*) *martini* Withers, *Stramentum haworthi* (Williston) and *Squama spissa* Logan are known from the Senonian of Kansas. *Stramentum canadensis* (Whiteaves) (Withers, 1935) has been described from the Fort Benton group of Manitoba and recently Russell (1967) added a further Canadian species, ?*Calantica saskatchewanensis*, from the Bearpaw Formation of southwestern Saskatchewan. *Arcoscalpellum conradi* (Gabb, 1876) from the Vincentown Formation of New Jersey, must now be regarded as a Palaeocene form (Richards, 1958), which substantiates Withers' (1935) opinion that the scutum and carina of this resembled certain Tertiary species.

Students and collectors of the rich fauna of Upper Cretaceous sediments of Mississippi, Alabama and Tennessee made great use of Wade (1926) in the identification of fossils, despite its limitation to basal Ripley strata of Coon Creek, McNairy County, Tennessee. It was soon recognized that *Virgiscalpellum gabbi*, first recorded from Coon Creek, was present in the Ripley strata of Oktibbeha County, Mississippi, and that other barnacle types were also present.

The collections to be considered afford an aggregate of some 1493 valves; from these 46 different valves have been distinguished and are included in the following species:

Cretiscalpellum harnedi sp. nov.
  C. macrum sp. nov.
  C. vallum sp. nov.
  C. venustum sp. nov.
Arcoscalpellum bakeri sp. nov.
  A. campus sp. nov.
  A. hubrichti sp. nov.
  A. withersi sp. nov.
Virgiscalpellum gabbi gabbi (Pilsbry)
  V. gabbi apertus ssp. nov.
  V. sp.
  V. sp.
Brachylepas angulosa sp. nov.

This material not only allows nine new species and one new subspecies to be described, but also includes the first member of the sub-order Brachylepadomorpha to be recorded from the Western Hemisphere. The new material of *V. gabbi* allows us to add the scutum, tergum, carinal and rostral latera to the known valves of that species. Moreover, these valves show that *V. g. gabbi* is related to the Maastrichtian species *V. hagenowianum* (Bosquet) which occurs only at Maastricht.

Both Pilsbry (1933) and Withers expressed doubts whether or not the upper latus, figured by Withers (1935, p. 39, fig. 2, erroneously called a scutum by Wade, 1926) should be ascribed to *V. gabbi*. In his notes on the valves present in the original collections sent to the British Museum (Nat. Hist.), Withers had considered that this valve really belonged to the species here named *A. withersi* but in view of the additional material in the present collections, which bear a striking similarity to the upper latus of *V. darwinianum* (Bosquet) figured by Withers (1935, pl. 38, fig. 1) there seems little to support this opinion. Until such time as more material becomes available, these particular upper latera are here retained, with reservation, in *V.g. gabbi*. The present material from the Ripley Formation of Mississippi shows that the carina of *V. gabbi* is very variable in structure and carinae similar to the one Withers set aside in his notes as a new species are here regarded as a subspecies of *V. gabbi*. Also, a distinct scutum and tergum ostensibly from the Ripley Formation and Annona chalk respectively are described, but not named. These anomalies indicate that much remains to be learned of the genus *Virgiscalpellum*, particularly from the American Cretaceous. It is felt that extensive new collections are desirable to allow a re-study of the genus to be made.

The valves of *Arcoscalpellum hubrichti* have characters in common with both of the European Groups of *A. maximum* (J. de C. Sowerby) and *A. fossula* (Darwin); both *A. campus* and *A. withersi* have affinities with the Group of *A. fossula*.

Of the four species of *Cretiscalpellum* present, *C. vallum* is the best known; not only is it represented by numerous carinae, but also by eight other different valves. *C. macrum* and *C. venustum*, the geologically oldest species of the genus in the present collection, are known from only fifteen and four valves respectively, while *C. harnedi*, the youngest of the genus in this study, is represented by thirteen valves.

Withers (1927, 1935, 1953) and Cheetham (1963) have fully discussed the morphology and classification of fossil lepadomorph cirripedes and the latter has also provided a comprehensive survey of North American Tertiary species.

Following the practice adopted by Darwin, a carina, when present, has been selected as holotype.

ABBREVIATIONS

The following abbreviations relating to Museum and other collections have been used in the text: BMNH, British Museum (Natural History); MSU, Mississippi State University; PRI, Paleontological Research Institution.

SYSTEMATIC DESCRIPTIONS

Series CIRRIPEDIA Burmeister, 1834

Order THORACICA Darwin, 1851

Suborder LEPADOMORPHA Pilsbry, 1907

Family **SCALPELLIDAE** Pilsbry, 1916

Genus ***CRETISCALPELLUM*** Withers

1922 *Cretiscalpellum Withers* : (9), 9, 374.
1935 *Cretiscalpellum* Withers : 2, 144.

DIAGNOSIS: Scalpellidae with seventeen valves including four pairs of large and little differentiated, much overlapping lower latera; subcarina much larger than rostrum; carina with umbo apical.

TYPE SPECIES: *C. unguis* (J. de C. Sowerby).

RANGE: Aptian (Lower Greensand) to Maastrichtian.

Cretiscalpellum macrum sp. nov.
(Plate 1, Figs 1–6)

DIAGNOSIS: Carina thin, moderately arched with fine apico-basal ridge, acute basal angle. Tergum and scutum thin, tergum with carinal margin divided into upper and lower portions.

HOLOTYPE: A carina. BMNH In.64414. (Pl. 1, fig. 1), Upper Senonian, Mooreville Chalk; 3 miles E. of West Greene and 3 miles W. of Clinton, Greene County, Alabama.

MATERIAL: 15 valves:

BRITISH MUSEUM

In.64414.	Carina.	Holotype.	Pl. 1, fig. 1.	A5.
In.64415.	Scutum.	Paratype.	Pl. 1, fig. 3.	A1.
In.64416.	Tergum.	,,	Pl. 1, fig. 4.	A4.
In.64417.	Tergum.	,,	Pl. 1, fig. 6.	A8.

MISSISSIPPI STATE UNIVERSITY

1311.	Carina.	Paratype.	Pl. 1, fig. 2.	A8.
1312.	Tergum.	,,	Pl. 1, fig. 5.	A8.
1339–45.	7 Terga.	Paratypes.		

Localities: Type locality, 3 miles E. of West Greene and 3 miles W. of Clinton, c. ¼ mile N.E. of church, c. Centre SW¼ Sec. 31, T. 23 N., R.1 E., Greene County, Alabama. Other localities—Al; A4; A6; A7; A8. Horizon: Mooreville Chalk, Upper Senonian.

Description: *Carina* (Pl. 1, figs 1–2) length about three times the width; it is thin and a little bowed inwards, the lateral margins are straight or slightly hollowed. The basal angle is acute (c. 60°) and the growth lines are directed downwards at the lateral edges to produce a weak spur. The tectum, with a fine, slightly beaded apico-basal ridge, is broadly arched transversely, becoming slightly rounded and thickened at the sides. Fine longitudinal ridges, more prominent towards the side of the valve, make up the surface ornament. The inner surface is regularly concave and a thin ridge extends the length of the lateral margin.

Scutum (Pl. 1, fig. 3) thin and trapezoidal in outline, the width being about two thirds of the length. It is moderately convex transversely with a thin, sharp apico-basal ridge, another ridge of equal prominence passes from the apex to half way along the basal margin. The basal margin is moderately convex, it forms an angle of about 80° with the apex on the occludent side and nearly a right angle with the lateral margin. The occludent margin is evenly rounded and the apex is directed towards the tergum. The tergal margin is concave and thickened at the apex. The lateral margin is rounded and shorter than the tergal margin. The tergo- and basi-lateral angles are sharp. On the inner surface near the occludent side and above the adductor muscle pit there is a deep depression which overhangs on the tergal side. A groove extends a short way along the inner occludent and tergal sides.

Tergum (Pl. 1, figs 4–6) thin and sub-quadrate in outline; the length is about twice the width. A fine apico-basal ridge, steep on the carinal side, divides the valve slightly to the carinal side of the midline. Two folds, extend from the apex to the scutal margin; the lower fold reaching the edge about half way along and the upper fold about midway between this and the scutal angle. The two areas enclosed by the ridges bounding these folds and the occludent margin are flat. The occludent margin is straight and equal in length to the scutal margin, which is concave where the folds reach the edge and convex to the base. The scutal and carinal angles are sharp. The carinal margin is divided into two almost straight portions; the upper portion is about half the length of the lower. The surface is smooth or ornamented with fine longitudinal ridges. On the inner surface a short groove extends along the occludent and carinal edges and growth lines form a slightly overhanging slip at the apex. The reverse of the folds on the outer occludent side is plainly discernable.

Discussion: The carina may be readily distinguished from *C. venustum* by the rounded transverse section, the more obtuse angle of the basal margin and the thin, not rolled under, lateral margins. It differs from the later *C. harnedi* by the fine apico-basal ridge and sparser ornament. The nearest European species would appear to be *C. glabrum* (Roemer); the carina of *C. macrum* however, is much thinner, less arched transversely and has a much weaker apico-basal ridge, and the terga have two folds extending from the apex to the scutal margin.

The name of this species is derived from *macer*, thin.

Cretiscalpellum venustum sp. nov.

(Plate 1, Figs 7–9, 13)

Diagnosis: Carina with tectum strongly arched and with weakly developed parietes directed a little inwards and thickened; the apico-basal ridge is rounded and the basal margin is nearly straight.

Holotype: A carina. BMNH In.64418 (Pl. 1, fig. 7*a-b*), Upper Senonian, lower or middle Mooreville Chalk, Mt. Olive Church, Greene County, Alabama.

Material: 4 valves:

British Museum

In.64418.	Carina.	Holotype.	Pl. 1, figs 7*a-b*.	A7
In.64419.	Tergum.	Paratype.	Pl. 1, fig. 9.	A8

Mississippi State University

1313.	Carina.	Paratype.	Pl. 1, fig. 8.	A8
1346.	Carina.	,,		A6

Localities: Type-locality, 1·2 miles due E. of Mt. Olive Church and in SW$\frac{1}{4}$ of SW$\frac{1}{4}$ Sec. 32, T.22 N., R.1 E., Greene County, Alabama. Other localities—A6; A8.

Horizon: Lower or middle Mooreville Chalk, Upper Senonian.

Description: *Carina* (Pl. 1, figs 7, 9, 13) length approximately three times the width, nearly straight or a little bowed outwards, the sides being straight. The apex is acute and the basal angle is very wide (c. 120°). The tectum is strongly arched transversely and rounded at the lateral margins to form very weak parietes which are slightly rolled under to form a narrow ridge. Several rather prominent ridges extend along either side of the rounded apico-basal ridge; where this and the ridges forming the ornament are interrupted by the growth lines, they tend to be raised into low nodes. The inner surface is open to the apex and is evenly rounded.

Tergum (Pl. 1, fig. 9) rhomboidal in outline, the width being rather more than half the length. The apico-basal ridge is straight, steeper on the carinal side and situated slightly towards the carinal side of the midline. Two prominent folds extend from the apex to the scutal margin parallel to the occludent margin. The area between the apico-basal ridge and the lower fold is flat; the carinal side of the valve is flatly depressed. The occludent margin is straight and about as long as the scutal margin which is somewhat sinuous. The upper portion of the carinal margin is concave and shorter than the nearly straight lower portion which is about as long as the occludent margin. The carinal angle is sharp. The apico-basal ridge is slightly notched by growth lines and the surface is ornamented by numerous fine ridges distributed more or less evenly over the surface. On the inner surface very faint growth lines extend from the apex along the occludent and upper carinal edges. The reverse of the folds on the outer occludent side and a groove corresponding to the apico-basal ridge are prominent.

DISCUSSION: The carina of *C. venustum* is distinct from the other *Cretiscalpellum* species in the present collection. It has in the steep transverse section and the tendency for the intersection of the growth lines and longitudinal ridges to become beaded some affinity to the European species *C. striatum* (Darwin), but in the latter the parietes are stronger and not rolled under as in *C. venustum*.

The name of this species is derived from *venustus*—beautiful—in reference to the beaded ornament. *Cretiscalpellum* remains from the Mooreville Chalk appear to be quite rare, particularly when compared with the many hundreds of valves of *Arcoscalpellum hubrichti* that have been collected. The numerical ratio of *Arcoscalpellum* to *Cretiscalpellum* in these outcrops is approximately 200 : 1. With the accumulation of more material, it may well be found necessary to re-assess the specific identities of the scutum and terga here attributed to *C. macrum* and *C. venustum*.

Cretiscalpellum harnedi sp. nov.

(Plate 1, Figs 10–12)

DIAGNOSIS: Carina obscurely carinated, not divided off into parietes or intraparietes.

HOLOTYPE: A carina BMNH In.64421 (Pl. 1, figs 11*a-c*), Maastrichtian, Middle Ripley Formation, 1·5 miles E. of State College, Oktibbeha County, Mississippi.

MATERIAL: 13 valves:

BRITISH MUSEUM

In.64420.	Scutum.	Paratype.	Pl. 1, figs 10*a-b*.	M8
In.64421.	Carina	Holotype.	Pl. 1, figs 11*a-c*.	M3
In.64422.	Tergum.	Paratype.	Pl. 1, fig. 12.	M8
In.64486.	Carina.	,,		M8

MISSISSIPPI STATE UNIVERSITY

1314.	Carina	Paratype		OC.2
1315.	Tergum.	,,		M8
1347–51.	5 Carinae	Paratypes.		
1352–53.	2 terga	,,		

LOCALITIES: Type locality, 1·5 miles E. of State College: probably N.W. corner of NE$\frac{1}{4}$ of NW$\frac{1}{4}$ Sec. 6, T.18 N., R.15 E., Oktibbeha County, Mississippi. Other localities—OC.1; OC.2; M2; M3; M8.

HORIZON: Ripley Formation, Maastrichtian.

DESCRIPTION: *Carina* (Pl. 1, fig. 11) length is from twice to three times the width; it is slightly bowed inwards and strongly arched transversely with an obscure, flatly rounded median keel; it is not divided off into parietes or intraparietes. The apex is blunt and the basal margin is obtusely angular, forming an angle of about 120°; the basi-lateral angle is narrowly rounded. The outer surface is ornamented with fine longitudinal ridges. The inner surface is deeply concave and the apex is open to the top, indicating that little or none of the valve projected freely.

Scutum (Pl. 1, fig. 10) trapezoidal in outline and slightly concave longitudinally.

The occludent margin is straight and the apex is not directed towards the tergum. The tergal margin is straight and shorter than the slightly concave lateral margin. The apico-basal ridge and another passing to the basal margin is straight and flatly rounded. A number of fine ridges, rather more numerous on the occludent side, make up the surface ornament. On the inner surface a slight groove above the adductor muscle pit extends towards the apex.

Tergum (Pl. 1, fig. 12) similar to that of *C. macrum*, but it is thicker and more elevated transversely. The apico-basal ridge is much rounded, steep on the carinal side and hardly at all raised on the occludent side. The occludent margin is thickened and raised to form a low ridge. The folds extending from the apex to the scutal margin are hollowed and bounded on the carinal side by broadly rounded ridges.

Discussion: Differences with *C. macrum* have been discussed above. The arched carina readily distinguishes it from that of *C. vallum*. The apico-basal ridge of the tergum is somewhat stronger and more rounded than that of *C. vallum*, and the folds on the occludent side are regular and more evenly spaced. Compared with *C. vallum*, the ridges on the scutum are sharper and the outer surface is not so strongly ornamented. In dorsal view the carina somewhat resembles *C. subcarinatum* Withers (1935, pl. 18, figs 12, 15), but this species has narrow parietes set abruptly inwards.

The species is named after the brothers Horace H. Harned, Jr., and Wentworth V. Harned, who contributed much of the material used in this work.

Cretiscalpellum vallum sp. nov.

(Plate 1, Figs 14–22; Plate 2, Figs 1–12; Text-fig. 1)

Diagnosis: Carinal margins produced to narrow wall-like parietes; portions of tectum on either side of the apico-basal ridge depressed; the other valves with well developed apico-basal ridge.

Holotype: A carina. BMNH In.64423 (Pl. 1, figs 15*a-b*, 17*a-b*). Upper Senonian, basal Annona or upper Coffee Formation, Tibbee Creek, Clay County, Mississippi.

Material: 168 valves:

British Museum

In.64423.	Carina.	Holotype.	Pl. 1, figs. 15*a-b*, 17*a-b*	M11
In.64424.	Subcarina.	Paratype.	Pl. 1, figs 22*a-b*.	M11
In.64425.	Scutum.	,,	Pl. 1, figs 20*a-b*.	M11
In.64426.	Tergum.	,,	Pl. 1, fig. 18.	M11
In.64427.	Upper latus.	,,	Pl. 2, fig. 11.	M11
In.64428.	Tergum.	,,	Pl. 2, figs 2*a-b*.	M11
In.64429.	Rostral latus.	,,	Pl. 2, fig. 7.	M11
In.64430.	Subcarinal latus.	,,	Pl. 2, fig. 8.	M11
In.64431.	Inframedian latus.	,,	Pl. 2, fig. 9.	A10
In.64432.	Upper latus.	,,	Pl. 2, fig. 10.	OC.6
In.64433–4.	2 Carinal latera.	,,	Pl. 2, figs 5–6.	M11
In.64435.	Tergum with small bivalve.	,,	Pl. 2, fig. 3.	M11

In.64482.	Carina with small bivalve.	,,		M11
In.64483.	Subrostrum.	,,	Pl. 2, fig. 12.	M11
In.64484.	Carina.	,,		M11
In.64485.	Scutum	,,		M11

Mississippi State University

1316.	Carina.	Paratype.	Pl. 1, figs 14*a-b*.	M11
1317.	Scutum.	,,	Pl. 1, fig. 19	M11
1318.	Tergum.	,,	Pl. 2, fig. 4.	M11
1319.	Upper latus.	,,	Pl. 1, fig. 21.	M11
1320.	Subcarina.	,,	Pl. 2, fig. 1.	M11
1321.	Carinal latus.	,,		M11
1354.	Sub-carinal latus.	,,		M11
1355.	Carina with small bivalve.	,,	Pl. 1, fig. 16.	M11
1427.	Scutum.	,,		M11
1428.	Tergum.	,,		M11
	26 Carinae.			
	21 Scuta.			
	86 Terga.			
	1 Upper latus.			
	6 Carinal latera.			
	1 Subcarina.			

Localities: Type locality, 4½ miles S. of West Point, south valley wall of Tibbee Creek, E. of U.S. Highway 45-W, NE¼ of SE¼ Sec. 6, T.19 N., R.16 E., Clay County, Mississippi. Other localities—A10.

Horizon: Basal Annona or upper Coffee Formation, Upper Senonian.

Description: *Carina* (Pl. 1, figs 14–17) thin; approximately three times as long as wide. It is straight or very slightly bowed inwards in typical forms, but sometimes a little recurved at the apex. The median portion of the tectum is raised, rounded and topped by a thin apico-basal ridge; on either side of the rounded portion the tectum is flat or concave to the margin which is rounded and produced inward to form narrow wall-like parietes. The basal angle is sharp, c. 85°, the basal margins are slightly excavated and produced into a thin spur at each basi-lateral angle. The growth lines are raised into low ridges and fine apico-basal ridges are usually developed. On the inner surface the lower three quarters tend to follow the contours of the outer surface; the upper portion becoming infilled to form a shallow central groove which is flanked by another groove on each side.

Scutum (Pl. 1, figs 19, 20) trapezoidal in outline and the width is about three-quarters of the length. The apex is acute and bowed towards the tergum. The apico-basal ridge is moderately to strongly developed; it is rounded at the apex, but rapidly splays out and becomes almost flattened at the base. A second, sharper ridge extends from the apex to the basal margin and is displaced a little towards the occludent side of the midline. Between these two ridges the valve is almost flat;

it is rounded on the occludent side and flatly depressed on the tergal side. Longitudinally it is almost flat, or distinctly concave toward the apex. The basi-lateral angle is narrowly rounded. The basal margin is almost straight. The rostral angle, which is sharp in young valves, becomes very slightly produced as growth advances. The occludent margin is regularly convex. The tergal margin is short, thickened and slightly concave. The tergo-lateral angle is sharp and the tergal margin is inclined with the lateral margin at about 120°. The lateral margin is longer than the tergal margin and slightly concave. The growth lines are not prominent. The surface ornament consists of numerous longitudinal ridges, which are generally stronger on the occludent side of the second ridge. On the inner surface a small pit overlaps the adductor muscle pit and a thin ridge extends a little way down from the apex on each side.

Tergum (Pl. 1, fig. 18; pl. 2, figs 2–4) thin and rhomboidal in outline. A curved apico-basal ridge, sharp on the carinal side, is situated about two thirds of the width of the valve towards the carinal margin. The valve is widely and flatly raised along the occludent margin which is bordered by a narrow depression followed by a ridge bordered by another depression. The occludent margin and the shorter upper carinal margin are generally almost straight; the lower carinal margin is straight or slightly sinuous, longer than the upper carinal margin and about the same length as the scutal margin, which is slightly produced where the apico-scutal fold reaches the edge, it is concave in its upper half and somewhat convex in its lower half. In some instances the scutal margin and the apico-basal ridge is produced a little beyond the lower carina margin. Both the carinal angle and that formed by the occludent and scutal margins are sharp. The outer surface is ornamented with obscure longitudinal ridges. The inner occludent and upper carinal edges are narrowly marked with growth lines which form a slightly overlapping fold and the inner upper carinal edge has a peculiar narrow and deep median depression.

Upper latus (Pl. 1, fig. 21; Pl. 2, figs 10, 11) is triangular in outline with the sides almost equal in length. The tergal margin is slightly concave and bounded by a strong, flattened ridge which is slightly grooved along the midline. From this ridge the valve is flat, becoming slightly turned inwards at the basi-scutal angle. The scutal margin is slightly convex and the basal margin is almost straight. A juvenile valve (Pl. 2, fig. 11) is ornamented with strong apico-basal ridges, but in the larger valves they have become almost obsolete.

Sub-carina (Pl. 1, fig. 22; Pl. 2, fig. 1) the width a little more than half the length; it is slightly bowed inwards. The lateral margins are straight; the basal angle is very wide (c. 120°) and the basal margins are excavated. A short spur is produced at the basi-lateral angle. The median ridge is sharp; there is no rounded prominence as seen on the carina and the portions on either side are regularly concave to the lateral margins which are slightly thickened, but not produced to form parietes. The growth lines are a little more prominent than the ornament of longitudinal ridges. On the inner surface a little more than half the length of the valve is marked with growth lines.

Carinal latus (Pl. 2, figs 5, 6) sub-oblong in outline; the height is about two thirds of the length. It may be longitudinally and transversely slightly bowed inward, or longitudinally concave. The apico-basal ridge is curved, strong and barely produced at the basi-inframedian latus angle. The upper margin is concave and the carinal margin is convex; both are bounded by a very thin groove. The basal margin is straight or slightly convex. The inframedian latus margin, which is straight, is shorter than the carinal margin and inclined to the basal margin at an angle of about 117°.

Sub-carinal latus (Pl. 2, fig. 8) sub-triangular in outline and about as wide as high. Transversely it is convex and longitudinally concave. The apex is acute and directed towards the inframedian latus. The carinal margin is convex and about the same length as the concave upper margin; both these margins have rounded edges. A strong ridge passes from the apex to the basi-inframedian latus angle which is slightly produced. The basal margin is slightly convex. The straight inframedian latus margin is half the length of the basal margin and inclined to it at about 130°.

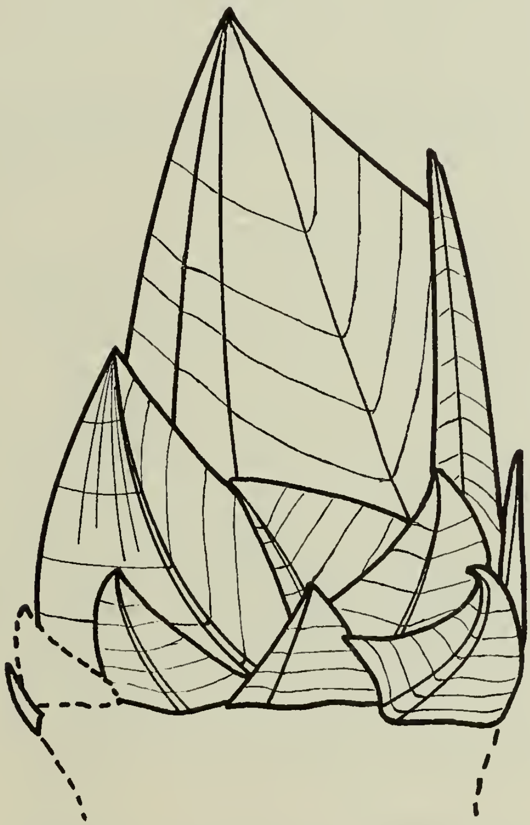

Fig. 1. Reconstruction of *Cretiscalpellum vallum* sp. nov. with the presumed shape of the rostrum in dotted line.

The principal differences between this valve and the carinal latus are in the proportions of the length to width and the less steeply inclined inframedian latus margin.

Subrostrum? (Pl. 2, fig. 12); a unique valve almost triangular in outline with a rounded apex, straight sides and chamfered, broadly curved basal margin; longitudinally and transversely it is very slightly arched and there is a weakly developed median apico-basal ridge, with exceedingly fine striae either side. The growth lines are broken by a series of deeper grooves forming a pattern of elongated hexagonal figures. On the underside two thin ridges either side of the apex extend down to a broad depressed area which follows the lateral edges.

In the absence, in the present collection, of valves corresponding to typical *Cretiscalpellum* rostra, the precise position of this valve remains doubtful. It is comparable however, with valves of similar shape belonging to *C. unguis* (J. de C. Sowerby) from the Gault, which also have a similar hexagonal ornament and chamfered basal margin. These valves are known, by associated material, to have fitted below the rostrum in much the same position as the subcarina fits below the carina.

Rostral latus (Pl. 2, fig. 7) triangular in outline and convex both longitudinally and transversely. A rounded ridge passes from the apex, which is acute, to the basal margin. The rostral margin is convex. The basal margin is concave between the ridge and the rostral angle and convex from the ridge to the inframedian latus angle. The inframedian latus margin is concave.

Inframedian latus (Pl. 2, fig. 9) sub-triangular in outline; on the carinal side a strong ridge extends from the rounded apex to the basal margin and on the carinal side of this ridge the valve is depressed. Longitudinally it is concave. The carinal margin is slightly concave and produced at the basi-carinal angle. The basal and rostral margins are convex.

Discussion: The carina of this species is quite unlike that of any other known *Cretiscalpellum*. The flattened tectum and narrow parietes superficially resembles the illustration of *Arcoscalpellum simplex* (Darwin, 1851, p. 39, pl. 1, figs 9*a*–*c*), but in *C. vallum* the parietes are set vertically to the lateral margin and not turned inward; also, in *C. vallum* the parietes extend to the basal margin. The tergum, like that of many other species, shows some variation in outline; forms range from rhomboidal with straight margins and an almost straight apico-basal ridge, to trapezoidal with both margins and apico-basal ridge slightly curved.

Three of the carinae, a scutum and a tergum examined, have on the outer surface the remains of a small unidentified bivalve (Pl. 1, fig. 16; Pl. 2, fig. 3). In every case distortion of the valve occurred to accommodate the growth of the mollusc, indicating that the barnacle played the part of 'host' whilst still alive.

The specific name alludes to the walled nature of the parietes of the carina.

Genus *ARCOSCALPELLUM* Hoek, 1907

1907 *Arcoscalpellum* Hoek; 1 (31*a*), 59.

1953 *Arcoscalpellum* Hoek; Withers, 3, 199.

Diagnosis: Scalpellidae with the rostral latus low and wide, twice as wide as high, with sub-parallel basal and scutal margins: inframedian latus generally smaller than the other latera, triangular, hour-glass shape or irregular; rostrum comparatively large in the fossil forms, but small or wanting in the Recent forms; carina with the umbo invariably apical; valves in some fossil forms 15, and in Recent forms 14 or 13 in number.

Type species: *A. michelottianum* (Seguenza) = *A. velutinum* (Hoek).

Range: Aptian (Lower Greensand) to Recent.

Arcoscalpellum hubrichti sp. nov.

(Plate 2, Figs 13–20; Plate 3, Figs 1–9; Text-fig. 2)

Diagnosis: Carina moderately to strongly arched transversely and a weakly developed apico-basal ridge. Ridges separate the tectum from the parietes and the parietes from the intraparietes; intraparietes comparatively wide and extending to base of parietes; the base forms almost a right angle, apex open; tectum and parietes ornamented with fine ridges, intraparietes furrowed; growth lines prominent.

Holotype: A carina. 6072PRI. (Pl. 2, figs 13*a–c*), Upper Senonian, Mooreville Chalk; 1½ miles N. of West Greene, Greene County, Alabama.

Material: 485 valves:

British Museum				
In.64436–7.	2 Scuta.	Paratypes.	Pl. 2, figs 16*a–b*, 17.	A7
In.64438.	Carina.		Pl. 2, figs 14*a–b*.	A6
In.64439.	Tergum.		Pl. 3, fig. 3.	A1
In.64440–2.	3 Carinal latera.	Paratypes.	Pl. 3, figs 6, 8*a–b*, 9.	A7
In.64443–4.	2 Upper latera.	,,	Pl. 3, figs 4, 5.	A7
In.64445.	Upper latus.	Paratype.		A7
In.64491–2.	2 Carinae.			A1
In. 64493–4.	2 Terga.			A6
Paleontological Research Institution				
6072PRI.	Carina	Holotype.	Pl. 2, figs 13*a–c*.	A1
6073*a–b*PRI.	2 Carinae.	Paratypes.	Pl. 2, figs 20*a–b*, Pl. 3, fig. 7.	A1
6074PRI.	Tergum.	Paratype.	Pl. 3, fig. 1.	A1
6082PRI.	25 Carinae & 7 terga.	Paratypes.		A1
Mississippi State University				
1323.	Carina.			A1
1324.	Tergum.		Pl. 3, fig. 2.	A3
1325.	Scutum.	Paratype.	Pl. 2, fig. 18.	A7
1356–7.	2 Scuta.	Paratypes.		A7

1358.	Associated carina & tergum.		Pl. 2, fig. 15.	A7
1359.	Upper latus.	Paratype.	Pl. 2, fig. 19.	A3
1360–62.	3 Upper latera.	Paratypes.		A7
1363–65.	3 Carinal latera.	,,		A7
	221 Carinae.			
	34 Scuta.			
	127 Terga.			
	3 Upper latera.			
	36 Carinal latera.			

LOCALITIES: Type-locality, Approx. S.W. corner SE$\frac{1}{4}$ of NE$\frac{1}{4}$ Sec. 27, T.23 N., R.1 W., on public road (through W.M. Steele land), 1$\frac{1}{2}$ miles N. of West Greene, Greene County, Alabama. Other localities—A2; A3; A4; A5; A6; A7; A8; A9; A11; M12.

HORIZON: Mooreville Chalk, Upper Senonian.

DESCRIPTION: *Carina* (Pl. 2, figs 13, 14, 20; Pl. 3, fig. 7) robust, moderately to strongly bowed inwards and widening comparatively rapidly from the apex. The width of the tectum is about one fifth the length of the valve; transversely it is moderately to strongly arched, with a weakly developed apico-basal ridge which tends to become obsolete towards the base as growth advances. Stronger, rounded ridges, each composed of two or three parallel minor ridges, separate the tectum from the parietes. The parietes are rather wide, being about half the width of the tectum; they are concave and inclined slightly outwards. The intraparietes extend to the base of the parietes from which they are separated by a prominent rounded ridge; they are inclined almost at right angles to the tectum and are concave, particularly towards the base. At their widest point they are a little more than twice the width of the parietes. The parietes and intraparietes together measure more than half the greatest width of the tectum. The side of the valve measured from the median ridge to the inner edge is deep, varying from about 60% of the width in young valves, to about 75% as growth advances. On reaching the basal margin the tecto-parietal and stronger parietal-intraparietal ridges frequently produce prominent knobbly spurs. The inner margin is thick and somewhat sinuous. The outer surface of the tectum and parietes is ornamented with exceedingly fine ridges. Equally fine longitudinal furrows intercept the growth lines on the intraparietes. The growth lines are prominent and slightly ridged. The basal margin forms an angle of about 90°. On the inner surface the valve is open for almost its entire length indicating that only a little of the beak-like apex projected freely.

Scutum (Pl. 2, figs 16–18) thin and trapezoidal in outline; the width being about two thirds of the length. The apico-basal ridge is weakly developed and flatly rounded. Transversely it is flat from the apico-basal ridge to near the occludent margin where it becomes convex; it is flatly depressed on the tergal side. The apex is acute. The occludent margin which is evenly convex, is slightly thickened and bounded by a shallow trough. The rostral angle is sharp and somewhat attenuated.

The basal margin is concave. The basi-lateral angle is bluntly rounded and sometimes slightly produced; the lateral margin is boldly sinuous. The tergal margin, which is straight and shorter than the lateral margin, is deflected into a thin ridge bounded behind by a shallow, tapering furrow.

The surface ornament consists of numerous fine longitudinal ridges which are stronger on the tergal side of the apico-basal ridge. The adductor muscle pit is moderately developed; above, on the occludent side is a slim pit, divided by a faint, sinuous ridge, and bounded by a stronger ridge on the tergal side.

Tergum (Pl. 3, figs 1–3) is elongated and sub-lanceolate in outline. The length ranges from about two and a quarter to two and a half times the width. The apical portion is slender and bowed away from the scutum. A fine apico-basal furrow divides the valve almost along its midline. It is bounded on the scutal side by a low,

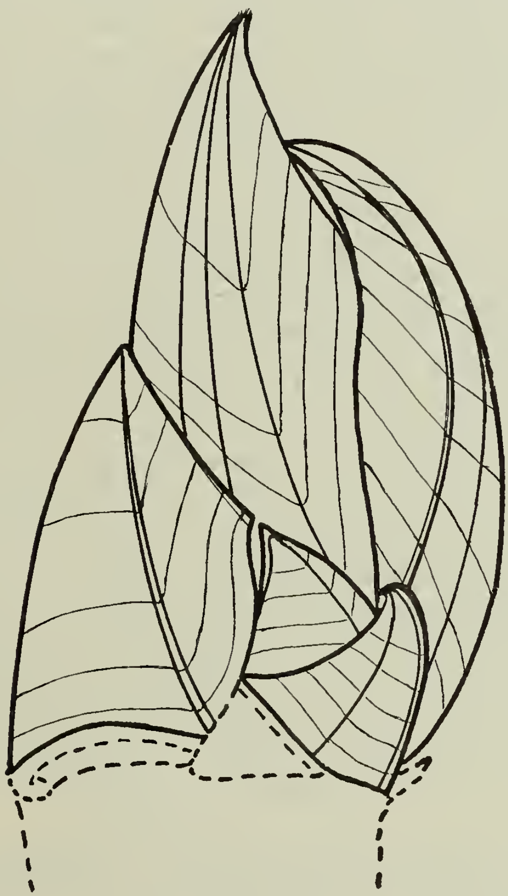

FIG. 2. Reconstruction of *Arcoscalpellum hubrichti* sp. nov. with the presumed shapes of the rostral and inframedian latera and subcarina in dotted lines.

broadly rounded ridge, and a depression separates this ridge from a thickened area bordering the occludent margin. A fine rounded ridge, more noticeable in the smaller valves, extends along the depression from the apex to the scutal margin. The carinal side of the valve is thin and flat. The occludent margin is evenly rounded and equal in length to the scutal margin which may be either rounded or slightly hollowed.

The occludent/scutal angle is obtusely rounded. The carinal margin is distinctly divided into two portions; the upper is concave and the lower, longer portion may be either straight or slightly convex. The carinal angle is broadly rounded. The surface ornament consists of a series of very weak furrows radiating from the apex. The growth lines are fairly coarse and form an acute angle at the midline. The inner occludent and carinal edges are very narrow and marked with growth lines which tend to overlap and produce a slight fold. Very weakly developed longitudinal ridges extend a short distance from the apex. A broad, tapering depression on the occludent side of the midline extends to the scutal margin.

Upper latus (Pl. 2, fig. 19; Pl. 3, figs 4, 5) sub-triangular in outline with the basi-tergal angle broadly rounded. It is transversely and longitudinally slightly convex. A depression, widening towards the base borders the convex tergal margin, which is raised into a slight slip. A ridge bounded by a groove and sometimes a second ridge borders the broadly concave scutal margin. A ledge formed round the tergal and scutal margins becomes thickened and produced beyond the umbo as growth advances. Some variation appears in these ledges in valves of similar size; they may be turned more or less at right angles to the margin, or turned under on the tergal side and deflected widely outward on the scutal side. The basal margin is broadly convex. The growth lines are prominent and, at intervals, widely spaced; they interrupt a few fine longitudinal ridges, which are rather more numerous on the median portion of the valve.

Carinal latus (Pl. 3, figs 6, 8, 9) sub-triangular in outline and transversely and longitudinally convex. The umbo is apical and turned towards the upper latus. A flange developed beneath the upper margin may be directed inwards or deflected obliquely outwards with its apex pointing to the upper latus; this variation occurs in valves of the same growth size. The carinal margin is convex, it is slightly longer than the strongly concave upper margin and generally shorter than the basal margin. The basal margin is weakly convex or nearly straight and sometimes convex on the inframedian side where a rounded ridge extending from the umbo reaches the basal margin. A ridge bounds the carinal margin and the basi-tergal angle is slightly produced; the growth lines on the carinal side of this ridge are upturned. An equally strong ridge bounds the upper margin. The growth lines are rather coarse and fine ridges curve from the apex to the basal margin.

Discussion: The carina of *A. hubrichti* differs from that of *A. withersi* in being wider in relation to its length; by having longer intraparietes; and in becoming splayed out towards the base. The tergum and scutum of *A. hubrichti* are much less robust and, in the tergum the apico-basal fold is central.

A. hubrichti has affinities with *A. fossula* (Darwin), but the carina differs from that of *A. fossula* in having weaker ridges separating the tectum from the parietes, which are less sharply inclined to the tectum and are partly visible when viewed from above. In this respect the carina of *A. hubrichti* resembles that of *A. maximum sulcatum* (J. de C. Sowerby), but an examination of the cross section shows the walls (comprising the parietes and intraparietes) of the latter species generally to be inclined away from the median ridge which is distinctly arched, whereas comparison with the cross section of *A. fossula* (Darwin, 1851, Pl. 1, fig. 4*h*) shows that the walls of both *A. fossula* and *A. hubrichti* (Pl. 3, fig. 10) extend almost parallel from the slightly arched tectum. The sections of carinae of *A. m. sulcatum* figured by Withers (1935, pl. 32, figs 5*c* & 8*b*) are somewhat misleading, since they are taken *below* the maximum development of the intraparietes. The terga of *A. hubrichti* agree very closely with those of *A. fossula*, but differ from those of *A. maximum* (J. de C. Sowerby)—no terga are known of the subspecies *sulcatum*—in maintaining distinct upper and lower carinal margins as growth advances, with no tendency towards developing the crescent shaped appearance of larger specimens of *A. maximum*.

The species is named after Mr Leslie Hubricht, of Meridian, Mississippi, who collected the original material in 1962 and donated it to the Palaeontological Research Institution, Ithaca, New York.

Arcoscalpellum bakeri sp. nov.

(Plate 3, Figs 10–13)

Diagnosis: Carina moderately to strongly bowed inwards; the tectum rounded, with an obscure median ridge; parietes flattened and not easily distinguished from the tectum; intraparietes narrow and inturned except apically where they are produced into a strong ridge.

Holotype: A carina. BMNH In.64446 (Pl. 3, figs 10*a–c*), Maastrichtian, Ripley Formation; Barr Pasture, Oktibbeha County, Mississippi.

Material: 61 valves:

British Museum					
	In.64446.	Carina.	Holotype.	Pl. 3, figs 10*a–c*.	M4
	In.64447.	Carina.	Paratype.	Pl. 3, figs 11*a–b*.	M3
	In.64448.	Carina.	,,	Pl. 3, figs 12*a–b*.	M4
	In.64496.	Carina.	,,		OC.7
	In.64449.	Tergum.	,,	Pl. 3, fig. 13.	M2
Mississippi State University					
	1326.	Carina.	Paratype.		M3
		56 Carinae.			

Localities: Type locality, Barr Pasture, N.W. corner of NE¼ of NW¼ Sec. 6, T.18 N., R.15 E., Oktibbeha County, Mississippi. Other localities—OC.1; OC.2; M2; M3; M5; M9.

Horizon: Middle Ripley, Maastrichtian.

DESCRIPTION: *Carina* (Pl. 3, figs 10*a–c*, 11*a–b*, 12*a–b*) robust and moderately to strongly bowed inward. The length is about four times the width, becoming rapidly splayed out towards the base. The basal margins are slightly rounded and form almost a right angle. Transversely, it is strongly rounded apically, becoming less so towards the base, with a weakly developed apico-basal ridge which sometimes becomes obsolete as growth advances. The parietes are narrow, less than half the width of the tectum, with which they are almost confluent, and much flattened; an obscure ridge separating the tectum from the parietes may be discerned in unworn individuals. The intraparietes are very narrow and almost as long as the parietes, from which they are inclined inward at about 90°, leaving a sharp dividing ridge. As growth advances the apical portions become inflected at a less acute angle and the sides coalesce to form a strongly projecting ridge which usually extends to one third and sometimes a half the length of the valve from the apex. The growth lines are generally not prominent on the tectum and parietes, on the intraparietes they are sharply upturned. The tectum and parietes are ornamented with fine, close set ridges.

A young specimen (In. 64447), 9 mm in length, shows that while the apical portion of the intraparietes is thickened to an extent proportional with larger specimens, the degree of inflexion is slight and the valve is open almost to the apex.

Tergum (Pl. 3, fig. 13) sub-rhomboidal in outline and about twice as long as wide. An obscure, bluntly rounded, almost straight apico-basal ridge is situated more than one third of the width of the valve from the carinal margin. On either side of the ridge the valve is flatly depressed, being steeper on the carinal side. The apex on the only known specimen has been abraded, but was probably bluntly rounded. A slight, raised slip bounds the occludent margin which is moderately convex. The scutal margin is longer than the occludent and is slightly concave in its upper half and convex in its lower half. The upper carinal margin is convex and about half the length of the nearly straight lower portion. The carinal angle is moderately sharp. A very faint groove extends from the apex to near the base of the scutal margin and between this and the apico-basal ridge extend several fine ridges.

DISCUSSION: The carina may be readily distinguished from that of the other species of *Arcoscalpellum* here described by the inflected intraparietes and the infilled, strongly ridged apical portion. These valves show some similarity to Darwin's *S. maximum* var. *cylindraceum* (= *A. maximum solidulum* Steenstrup), figured in Withers, 1935, (Pl. 33, figs 1*a–c*) from the Upper Senonian, *B. mucronata* Zone of Norwich, but differ in the bolder development of the apical ridge and the total infilling of the median cleft at the apex, except in quite juvenile specimens. They differ completely from the massively developed forms of *A. m. solidulum* from the *B. mucronata* Zone of Rügen in which, again, no ridge is present.

This species is named after Mr R. Baker, formerly of the Department of Palaeontology at the British Museum (Natural History), whose constant helpfulness did much to encourage me in my studies.

Arcoscalpellum campus sp. nov.

(Plate 3, Figs 14–16; Plate 4, Figs 1–4)

DIAGNOSIS: Carina very narrow; tectum flattened; parietes narrow; intraparietes set inward from parietes and reaching their greatest width one fourth the distance from the apex.

HOLOTYPE: A carina. BMNH In.64452. (Pl. 3, figs 14*a–b*, Pl. 4, fig. 4) Maastrichtian, Ripley Formation, Bardwell Pasture, Oktibbeha County, Mississippi.

MATERIAL: 59 valves:

BRITISH MUSEUM

In.64450.	Scutum.	Paratype.	Pl. 4, fig. 1.	M5
In.64451.	Tergum.	,,	Pl. 4, figs 2*a–b*.	M5
In.64452.	Carina.	Holotype.	Pl. 3, figs 14*a–b*; Pl. 4, fig. 4.	M5
In.64453.	Carinal latus.	Paratype.	Pl. 3, figs 16*a–b*.	M4
In.64489.	Scutum.	,,		M5
In.64490.	Tergum.	,,		M3

MISSISSIPPI STATE UNIVERSITY

1327.	Carina.	Paratype.		M3
1328.	Scutum.	,,	Pl. 3, figs 15*a–b*.	M5
1329.	Tergum.	,,	Pl. 4, fig. 3.	M4
1366–73, 1429.	9 Carinae.	Paratypes.		
1374–94.	21 Scuta.	,,		
1395–1414.	20 Terga.	,,		

LOCALITIES: Type locality, Bardwell Pasture, S.W. corner of NE$\frac{1}{4}$ of SW$\frac{1}{4}$ Sec. 6, T.18 N., R.15 E., Oktibbeha County, Mississippi. Other localities—OC.1; OC.2; OC.7; M1; M3; M6; M8; M9.

HORIZON: Ripley Formation, Maastrichtian.

DESCRIPTION: *Carina* (Pl. 3, fig. 14; Pl. 4, fig. 4) moderately bowed inwards and very narrow; the width being from one sixth to one fifth of the length. The basal angle is about 70° and the margins are straight. The tectum is much flattened and gently convex; an almost obsolete apico-basal ridge, which is not raised above the general surface, is delineated by faint grooves. The tectum is separated from the parietes by low, rounded ridges; the parietes are slightly concave and less than half the width of the tectum, with which they are set almost at right angles. The intraparietes are set a little inward from the parietes and are separated from them by a weak ridge; they are almost as long as the parietes, but reach their greatest width at the apical fourth of the length of the valve, where they are as wide as the tectum measured immediately above. Exceedingly fine ridges ornament the tectum and a few occur on the parietes. The inner margin is regularly concave and is open for almost its entire length.

Scutum (Pl. 3, fig. 15; Pl. 4, fig. 1) is thin, trapezoidal in outline and twice as long as wide. Transversely it is moderately convex, being much steeper on the occludent side. Longitudinally, there is a slight median concavity which produces a 'saddle backed' effect; when laid on a flat surface the valve rocks between the tergo-lateral and rostral angles. The apex is acute. The apico-basal ridge is very slight, hardly at all raised and rounded. The basal margin is concave and at right angles to the lateral margin. The occludent margin is very slightly thickened, evenly concave and inclined towards the tergal side. The tergal margin is nearly straight. The tergo-lateral angle is sharp and barely produced, it is inclined with the lateral margin at about 130°. The lateral margin almost equals the tergal margin in length and may be slightly convex or concave. The outer surface is almost smooth; a few longitudinal ridges are generally more prominent on the tergal side. On the inner suiface a broad triangular depression, bisected by a thin ridge on the tergal side, extends above the adductor muscle pit to the apex.

Tergum (Plate 4, figs 2–3) thin and sub-triangular in outline; the length slightly exceeds twice the width. A narrow apico-basal fold is situated close to the carinal margin and bowed slightly towards the scutal side. A thin ridge extends from the apex to the scutal margin, bisecting the edge a little to the occludent side of halfway. The valve is slightly depressed on the occludent side of the apico-basal fold, longitudinally it is almost flat. The occludent margin is broadly convex and about the same length as the scutal margin which is slightly concave or sinuous. The scutal angle is obtusely rounded. The carinal margin is generally nearly straight, but sometimes slightly concave in its upper half and broadly convex in its lower half. The surface may be smooth or ornamented with exceedingly fine longitudinal ridges. On the inner surface a thin ridge extends along the occludent side and upper part of the carinal side. A broad ridge, corresponding to the area between the scutal ridge and the occludent margin on the outer surface, extends parallel with the occludent edge. A few growth-lines line the apex, forming a slight overhang, and on some valves hair-like muscle attachment ridges extend a short distance from the apex.

Carinal latus (Pl. 3, fig. 6) triangular in outline. The umbo is acute and turned towards the upper latus, as is the apex of a flange projecting inward below the umbo. The upper margin is moderately concave and shorter than the carinal margin. The carinal margin is strongly convex; the edge is rounded and inflected sharply inwards, the inflected part is bisected longitudinally by a groove. The basal margin is straight for a very short distance on the carinal side, concave in the lower part of the inframedian latus side and upturned toward the upper margin. A comparatively wide part of the valve on the carinal side is raised to form a flat ridge; another, rounded ridge bounds the upper margin and between these ridges the valve is flat. Longitudinally it is flat.

Discussion: The carina may be distinguished from *A. withersi* and *A. hubrichti* by its narrow width, the flatness of the tectum and narrow, inset intraparietes. The 'saddle-backed' section and low apico-basal ridge distinguishes the scutum, while the tergum differs in its lighter build from *A. withersi*, and from *A. hubrichti* in the proximity of the apico-basal fold to the carinal margin.

Among European forms *A. campus* closely resembles *A. comptum* (Withers), of the Group of *A. fossula* (Darwin) from the Aptian and Albian, Gault (Collins, 1965) of S.E. England, but the carina of *A. comptum* is rather more arched transversely and the intraparietes are inflected inwards. The tergum agrees very well in general outline, but the surface ornament is much weaker in *A. campus*, although the portion between the apico-basal fold and scutal ridge is almost plain in both species. The more noticeable difference occurs on the underside, however, where in *A. comptum* the apical growth lines are stronger and several distinct muscle attachment ridges extend from the apex.

The specific name *campus* has a threefold application; it alludes to the flattened tectum of the carina and may be referred to the Bardwell Pasture (type) locality, which is near to the Mississippi State University Campus.

Arcoscalpellum withersi sp. nov.

(Plate 3, Figs 17, 18; Plate 4, Figs 5–15)

DIAGNOSIS: Carina slightly bowed inward; tectum slightly arched apically, becoming flattened towards the base; parietes and intraparietes well developed in line with one another and inclined almost at right angles to the tectum. Other valves generally robust and much thickened.

HOLOTYPE: A carina. BMNH In.64456 (Pl. 4 figs 6*a–c*), Maastrichtian, Ripley Formation; Barr Pasture, Oktibbeha County, Mississippi.

MATERIAL: 325 valves:

BRITISH MUSEUM

In.64454–5.	2 Rostral latera.	Paratypes.	Pl. 3, figs 17–18.	M5
In.64456.	Carina.	Holotype.	Pl. 4, figs 6*a–c*.	M3
In.64457.	Tergum.	Paratype.	Pl. 4, fig. 11.	M3
In.64458.	Tergum.	,,		M3
In.64459.	Scutum.	,,	Pl. 4, fig. 8.	M4
In.64460.	Scutum.	,,		M3
In.64461.	Carinal latus.	,,	Pl. 4, figs 14*a–b*.	M4
In.64462.	Upper latus.	,,	Pl. 4, fig. 15.	M4
In.64463.	Carina (apical half)	,,	Pl. 4, figs 7*a–b*.	M3
In.64480.	Carina.			OC.7
In.64481.	Tergum.			M6

MISSISSIPPI STATE UNIVERSITY

1330.	Carina.	Paratype.	Pl. 4, fig. 5.	OC.7
1331.	Scutum.	,,	Pl. 4, figs 9*a–b*.	M3
1426.	Scutum.	,,	Pl. 4, fig. 13.	M4
1332, 1425.	2 Terga.	Paratypes.	Pl. 4, figs 10, 12.	M2
1333, 1424.	2 Rostral latera.	,,		M4
1415.	Carina.	,,		OC.7

OTHER MATERIAL (including many fragmentary valves) 115 carinae; 67 scuta; 125 terga; 10 rostral latera.

LOCALITIES: Type locality, Barr Pasture, N.W. corner NE$\frac{1}{4}$ of NW$\frac{1}{4}$ Sec. 6, T.18 N., R.15 E., Oktibbeha County, Mississippi. Other localities—OC.1; OC.2; OC.5; OC.7; M1; M2; M5; M6; M8; M9.

HORIZON: Ripley Formation, Maastrichtian.

DESCRIPTION: *Carina* (Pl. 4, figs 5–7) comparatively narrow and slightly bowed inwards; the length is about five times the width. The tectum is narrow and slightly arched apically, with a weakly developed apico-basal ridge which becomes almost flat as growth advances. A sharp ridge separates the tectum from the parietes, which are two thirds the width of the tectum, set almost at right angles to it and slightly splayed outwards. A fine ridge separates the parietes from the intraparietes. The intraparietes are in line with the parietes, thin and fairly short, being half the length of the valve; at their widest they are more than twice the width of the parietes measured immediately above. As growth advances the intraparietes sometimes extend slightly beyond the umbo. In some instances a pronounced rib-like growth line is developed on the intraparietes which, progressing outward from near the apex, may bisect the parietal/intraparietal ridge and continue obliquely across the parietes to the tectum. The basal margin is rectangular and forms an angle of about 74°. The tectum is ornamented with exceedingly fine ridges. The inner surface is deeply concave and open to the apex.

Scutum (Pl. 4, figs 8, 9, 13) trapezoidal in outline and generally robust. The width is from half to almost two thirds of the length according to growth size. The apex is blunt. The apico-basal ridge is bluntly rounded and steep on the tergal side; it is somewhat produced at the basi-lateral angle. Transversely it is flatly depressed on the tergal side and on the occludent side it is flat to near the margin, when it is evenly convex. The basal margin is sinuous and the rostral angle is slightly produced. The occludent margin is nearly straight and set almost at right angles to the base in young valves, but it is bowed toward the tergal side in larger valves; there is a shallow depression parallel to the edge. The tergal margin, which is short and straight, is bounded by a thin ridge. The tergo-lateral angle is barely produced and generally rounded; it is inclined with the lateral margin at about 130°. The lateral margin is generally convex and sometimes excavated at the angles. The surface ornament is composed of numerous, very fine longitudinal ridges. On the inner surface a shallow pit, inclined towards the apex on the occludent side, extends above the deep adductor muscle pit. A very shallow depression lies in the tergo-lateral angle.

Tergum (Pl. 4, figs 10–12) obtusely elongate in outline, rather flat and generally much thickened; the length is about three times the width. The apex is acute and narrowly rounded. A slight apico-basal fold is situated very close to the carinal margin. A slight fold extends from the apex to near the middle of the scutal margin and on the occludent side of this the valve is concave. The carinal margin is not divided into an upper and lower part, but is generally slightly convex at the apex and base, while the median portion is nearly straight. The occludent margin may be straight or slightly concave and is shorter than the scutal margin with which it forms an obtuse angle. The scutal angle is sharply to moderately rounded. The scutal margin is slightly concave in its upper half and convex in its lower half. The outer surface is usually ornamented with fine irregularly spaced longitudinal ridges. On the inner surface a fairly wide part of the carinal and occludent edges is marked with growth lines; both edges are steeply inclined inwards. In some valves the surface is slightly raised in line with the inner occludent edge, and in others there are a few short, fine longitudinal ridges.

Upper latus (Pl. 4, fig. 15) thin and sub-triangular in outline. The apex is slightly inclined towards the scutum, almost flat longitudinally and slightly convex transversely. The umbo is acute; a ledge formed below the tergal margin is inclined inwards and is narrower than that formed round the scutal margin which is inclined obliquely outwards. The tergal margin is slightly convex and somewhat shorter than the scutal margin which is moderately concave. It is bordered by a thin ridge, bounded by a shallow groove which broadens towards the basal angle. The basal margin is boldly convex on the scutal side, becoming almost straight on the carinal side. A faint ridge extends from the apex to the basi-carinal angle; some sharper, finer ridges are more crowded on the carinal side of this ridge than on the scutal side.

Carinal latus (Pl. 4, fig. 14) sub-triangular in outline. The umbo is acute and sharply turned toward the upper latus. The apex of the rather broad flange projecting below the umbo is hook-like and directed toward the carina. The upper margin is deeply concave and shorter than the carinal margin. The carinal margin, which is acutely convex at the apex, becomes almost straight. The edge is rounded and forms a thin ridge on the inner side. The basi-carinal angle is slightly produced and the basal margin is concave on the carinal side and rounded on the shorter inframedian latus side. A ridge runs from the apex to the basi-inframedian latus angle and another bounds the upper margin; several weaker ridges ornament the valve on the carinal side. The valve is convex on the carinal side of the apico-basal ridge and steeply compressed on the inframedian side. Longitudinally it is gently convex.

Rostral latus (Pl. 3, figs 17, 18) about twice as wide as high, much thickened and flat transversely. An obscure ridge extends from the apex to the lower part of the inframedian latus margin; on the rostral side of this ridge the valve is excavated and above it another obsolete 'ridge' extends to the middle of the inframedian latus margin; between this and the upper margin the valve is again excavated. The apical angle approaches 90°. The upper margin is slightly concave and bounded by a ridge. The rostral margin is inclined towards the inframedian latus, almost straight and bounded by a thin sharp ridge. The basi-rostral angle is rounded and the basal margin is slightly concave. The inframedian latus margin is slightly concave in its upper half and convex in its lower half.

Discussion: Differences with *A. hubrichti* have been discussed above. The carina differs from that of *A. campus* in that the intraparietes are wider and are in line with the parietes. The species clearly belongs to the Group of *A. fossula*; the carina agrees very closely with the Maastrichtian species *A. gracile* (Bosquet), but differs in being moderately carinated apically and the ridge separating the parietes from the intraparietes (which are inclined a little outwards in *A. gracile*) retains more or less the same thickness towards the base. These ridges are not so strongly developed in *A. withersi* as they are in *A. fossula.*

This species is named after the late Mr T. H. Withers who contributed so largely to our knowledge of fossil cirripedes.

Genus ***Virgiscalpellum*** Withers 1935

1935 *Scalpellum* (*Virgiscalpellum*) Withers, p. 283

1945 *Virgiscalpellum* Withers, (11), 12, p. 554

Diagnosis: carinal umbo sub-apical to sub-central; scutum with umbo sub-central to sub-basal; rostrum much elongated; known valves fourteen.

Type Species: *V. beisseli* (Bosquet & Müller).

Distribution: Lower Aptian ('Crackers', Lower Greensand) to Maastrichtian.

Virgiscalpellum gabbi (Pilsbry)

1926 *Scalpellum* sp. Wade: 191, pl. 62, figs 3, 4, (non figs 6, 7).
1926 *Scalpellum gabbi* Wade (*nom. nud.*) pag. cit.
1931 *Scalpellum gabbi* Wade (*nom nud.*): 20 (Opinion 118).
1933 *Scalpellum gabbi* Pilsbry: 284.
1935 *Scalpellum* (*Virgiscalpellum*) *gabbi* (Pilsbry): Withers: 298, figs 1, 2.
1945 *Virgiscalpellum gabbi* (Pilsbry): Withers: 554.
1953 *Virgiscalpellum gabbi* (Pilsbry); Withers: 16, 18, figs 26, 27.

Diagnosis: Carina angularly bent longitudinally, umbo situated from one fifth to a half the distance from the apex; valve strongly and narrowly convex transversely; inner margin open and concave to infilled; intraparietes marked off from parietes by a strong ridge. Surface ornamented with fine close-set ridges radiating from the umbo, the transverse growth ridges equally raised and prominent.

Virgiscalpellum gabbi gabbi (Pilsbry)

(Plate 4, Figs 16–18; Plate 5, Figs 1–11, 14; Text-fig. 3)

Diagnosis: Umbo of carina reaching to half the distance from the apex, wider above the umbo; markedly constricted laterally immediately below umbo; lower and upper limb of valve open to infilled.

Holotype: A carina (Wade, 1926, pl. 62, figs. 3–4) United States National Museum. No. 73114, Maastrichtian, Ripley Formation, Coon Creek, McNairy County, Tennessee.

Material: 354 Valves:

British Museum

In.64487.	Carina.		Pl. 5, figs 14*a–c*.	OC.1
In.64464.	Carina.		Pl. 4, figs 18*a–b*.	OC.1
In.64465–6.	2 Carinae.		Pl. 5, figs 9*a—b*.	M2
In.64467.	Scutum.	Paratype.	Pl. 5, figs 3*a–b*.	M2
In.64468.	Tergum.			M2

In.64469.	Tergum.		Pl. 5, fig. 4.	OC.2
In.64470.	Scutum.	Paratype.	Pl. 5, fig. 7.	M2
In.64471.	Scutum.	,,		M2
In.64472.	Tergum.		Pl. 5, figs 1*a–b*.	M2
In.64473.	Carinal latus.	Paratype.	Pl. 5, fig. 8.	
In.64474.	Upper latus.		Pl. 4, fig. 16.	
In.64475.	Rostral latus.	Paratype.	Pl. 5, fig. 6.	

MISSISSIPPI STATE UNIVERSITY

1334.	Carina.		Pl. 4, figs 17*a—b*.	M8
1416.	Carina.		Pl. 5, figs 10*a–b*.	M8
1335.	Tergum.		Pl. 5, fig. 2.	M2
1336.	Scutum.	Paratype.	Pl. 5, fig. 11.	M2
1337.	Rostral latus.	,,	Pl. 5, fig. 5.	M3
	112 Carinae.			
	69 Scuta.			
	154 Terga.			
	1 Rostral latus.			

LOCALITIES (Present collections): OC.1; OC.2; OC.3; M1; M2; M3; M4; M5; M6; M8; M9.

HORIZON: Ripley and basal Prairie Bluff Formations, Maastrichtian.

DESCRIPTION: *Carina* (Pl. 4, figs 17, 18; Pl. 5, figs 10, 14, 18) subject to considerable variation in structure. The position of the umbo varies from central in a specimen measuring about 10 mm in length, to one third the distance from the apex in larger specimens. The angle formed by the upper to the lower limb is between 52°–65°. In some valves the intraparietes are inflected inwards at a very early stage in growth; the inflection occurring immediately below the umbo and producing a waisted appearance (as seen in the figure of the Type; Withers, 1935, pl. 39, fig. 1). Growth may continue with this waist, or as is sometimes the case, the inward development of the intraparietes is continued until they unite at the midline. A thickening of the valve usually ensues along the lower limb, but sometimes the upper limb is affected also. In extreme instances the lower limb is fused solid with the exception of a thin median groove widening distally. Viewed from the side the valve is very slender when advanced infilling occurs early in growth. In other valves the intraparietes are thin, straight and almost parallel; on the inner surface, the valve is open and regularly concave for its entire length.

Scutum (Pl. 5, figs 3, 7, 11) trapezoidal in outline and generally thin, rarely much thickened. The apical part of the valve is much attenuated. The umbo is subcentral and situated a little nearer to the rostral angle; there is a prominent ridge curving slightly upwards and across the valve to the basi-tergal angle. Another strong ridge extends from the umbo to near the rostral angle, and on the rostral side of this ridge the valve is inclined inwards. A slight furrow bordered below by a ridge, extends from the umbo to a short distance from the apex on the tergal margin, and from this furrow to the occludent margin the valve is flat and directed outwards. The occludent margin is almost straight and the upper portion inclined slightly towards the tergal side. The basal portion of the basi-carinal margin is straight and stands almost at right angles to the occludent margin, the rest of the basi-carinal margin is sharply inclined upwards to the basi-tergal angle which is moderately to broadly rounded. The tergal margin is somewhat concave, with a little protuberance near the furrow extending from the umbo; it forms an angle of about 30° with the upper part of the basi-carinal margin. On the outer surface a number of fine ridges radiate from the umbo; they are more prominent in the lower half of the valve and in the region of the umbo. On the inner surface the inner occludent edge is narrow above and below the umbo, but below the umbo it is somewhat excavated. The adductor muscle pit, which is wide and deep, is overhung by a strong, wide ledge which extends upwards from the inner occludent edge and ends abruptly about one third the width of the valve from the tergal edge.

Tergum (Pl. 5, figs 1, 2, 4) obtusely triangular in outline and elongated, being more than two and a half times as long as wide; it is slightly curved towards the carina. An obscure apico-basal ridge, not to be seen in some valves, is situated less than one third the distance from the carinal margin. The occludent and scutal margins are slightly convex and about the same length. The concave carinal margin is only obscurely divided into two parts as the margin is abruptly inturned from the outer surface. The apex and basal angle are narrowly rounded. A prominent rounded ridge extends from the apex near and parallel with the occludent margin; another ridge, more prominent in some valves than in others, extends from the apex to the scutal margin midway between the outer and apico-basal ridges; there are numerous fine longitudinal ridges on the occludent half of the valve. On the inner surface the inner occludent and the inner upper carinal edge are narrow and almost equal in width, and marked with growth lines.

Carinal latus (Pl. 5, fig. 8) wider than high; the upper inner angle is produced upwards to form an acute angle. The carinal margin is very short and convex, it is turned over to produce a rounded edge, which on the inner surface overhangs a little on the carinal side of the umbo. The upper margin is long and concave. The basal margin is concave. The inframedian lateral margin is concave in its upper two thirds and the lower third is produced outwards with a narrowly rounded angle. A raised rounded ridge extends from the umbo to the upper inner angle and from this ridge the upper margin is abruptly inturned. A second ridge extends from the umbo to the inner angle of the basal margin; three much lighter ridges extend from the umbo to the inframedian latus margin.

Rostral latus (Pl. 5, figs 5–6) about twice as wide as high and strongly bowed inwards. A deep fold, ridged on the rostral side, extends obliquely from the apex to the lower part of the inframedian latus margin. The apical angle is acute and rounded. The upper margin is convex and the rostral margin truncated. The basal margin is concave and somewhat longer than the inframedian latus margin which is concave where the fold reaches the edge and convex to the very sharp angle with the upper margin.

The upper latera (Pl. 4, fig. 16) in the present collection add little to our knowledge of the valve, apart from extending the known distribution.

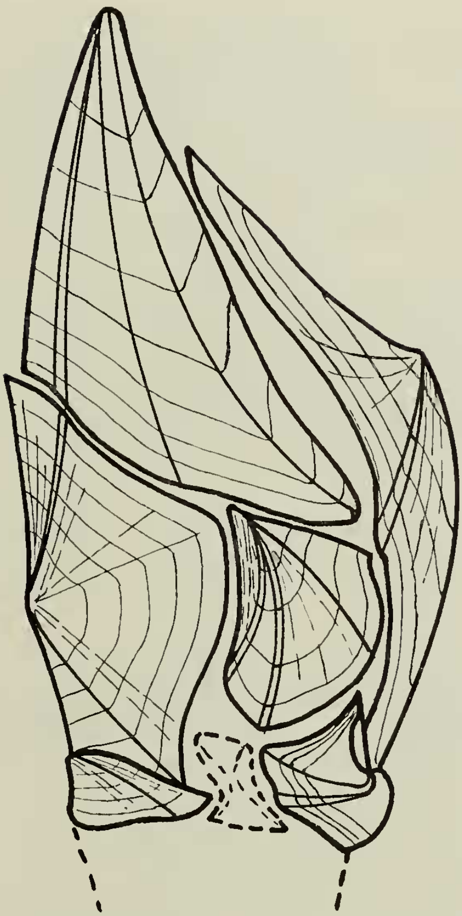

FIG. 3. Reconstruction of *Virgiscalpellum g. gabbi* (Pilsbry) with the presumed shape of the inframedian latus in dotted lines.

DISCUSSION: *V. gabbi* does not appear to have any close affinities with the species described by Pilsbry & Olssen (1951) from South America, but more closely resembles two European Maastrichtian species. The carina resembles that of *V. hagenowianum* (Bosquet), but differs in having the parietes divided from the intraparietes which are narrow and curved (not straight in the lateral view as in *V. hagenowianum*) and generally in being much thickened; whereas in its somewhat attenuated apex, straight occludent margin and general surface ornament, the scutum of *V. gabbi* approximates that of *V. radiatum* (Bosquet). So far, no scutum has been ascribed to *V. hagenowianum* and *V. radiatum* is known only by scuta. The similarities shown by the *V. hagenowianum* carina and *V. radiatum* scuta to corresponding valves of *V. gabbi* support Withers' opinion (1935, p. 297) that the *V. radiatum* scuta should belong to *V. hagenowianum*. With regard to the terga, those of *V. gabbi* appear to differ from *V. hagenowianum* only in having a stronger apico-scutal ridge set further from the occludent margin and a more prominent depression on the occludent side.

Rostral latera for only two species of *Virgiscalpellum* have hitherto been described; those here attributed to *V. gabbi* closely resemble *V. darwinianum* (Bosquet), but differ in having fewer ridges extending to the inframedian latus margin and in the more acute angle formed by that margin with the upper margin.

Virgiscalpellum gabbi apertus sub-sp. nov.

(Plate 5, Fig. 15)

DIAGNOSIS: Carina strongly and broadly convex transversely, umbo reaching one third the distance from the apex, narrower above the umbo; laterally nearly straight; inner surface broadly open throughout its length.

HOLOTYPE: A carina. BMNH In.64478 (Pl. 6, figs 17*a–c*), Maastrichtian, Ripley and basal Prairie Bluff, Catalpa Creek, Oktibbeha County, Mississippi.

MATERIAL: 10 valves:

BRITISH MUSEUM				
In.64478.	Carina.	Holotype.	Pl. 5, figs 15*a–c*.	OC.6
In.64488.	Carina.	Paratype.		M4
MISSISSIPPI STATE UNIVERSITY				
1338.	Carina.	Paratype.		M8
1417–23.	7 carinae.	Paratypes.		

LOCALITIES: Type locality, Catalpa Creek, NW$\frac{1}{4}$ of NE$\frac{1}{4}$ Sec. 25, T.18 N., R.14 E., Oktibbeha County, Mississippi. Other localities—OC.1; M4; M7; M8.

HORIZON: Ripley and basal Prairie Bluff, Maastrichtian.

DESCRIPTION: *Carina* (Pl. 5, figs 15*a–c*) very broad, the basal width being about a quarter of the length. The umbo is sharp and situated from one fifth to one third of the length of the valve from the apex. The apical and basal margins are broadly rounded. The tectum is not differentiated from the parietes; the upper and lower limbs are weakly carinated at the umbo, becoming evenly rounded distally. The upper limb is narrower than the lower, which splays out a little towards the base. The intraparietes are separated from the paiietes by a strong ridge and extend almost at right angles with the tectum. The inner margin is more or less divided into two portions, angularly bent just above the parietal ridge; the upper portion comprising the intraparietes, is almost straight and the lower portion is convex. The outer surface is ornamented with fine ridges and the growth lines are rather more prominent on the intraparietes than on the tectum. The inner surface is widely, deeply and regularly concave and open throughout the length of the valve.

DISCUSSION: The carina of *V. g. apertus* may most readily be distinguished from that of *V. g. gabbi* by the broadly open inner surface with little or no indication of the intraparietes turning in to form a waist below the umbo; it is wider in relation to length; the upper limb is comparatively shorter and the intraparietes are wider and usually straighter.

The trivial name refers to the open inner surface of the valve.

Virgiscalpellum sp.

(Plate 5, Fig. 12)

MATERIAL: A unique scutum, BMNH. In.64476.

LOCALITY: $4\frac{1}{2}$ miles S. of West Point, NE$\frac{1}{4}$ of SE$\frac{1}{4}$ Sec. 6, T.19 N., R.16 E., Clay County, Mississippi.

HORIZON: basal Annona or upper Coffee Formation, Campanian, Upper Senonian.

DESCRIPTION: Scutum sub-trapezoidal in outline and bowed outwards. The umbo is sub-central, being situated a little nearer to the base. A wide, indistinct fold extends from the umbo to the basi-tergal angle and above this fold the valve is concave to near the upper part of the occludent margin, which is rather widely raised and bounded below by an indistinct depression. The tergal margin is nearly straight and forms an angle of about 40° with the upper half of the occludent margin. The basal margin is very short, straight and inclined toward the tergum. The upper occludent margin is inclined with the lower occludent margin at an angle of about 67°; both margins are slightly convex. Very fine ridges extend from the umbo within the basi-tergal fold and the occludent depression, but on the central portion of the valve the ridges become so wide and depressed as to be outlined only by faint grooves. On the inner surface a broad, rounded ridge extends parallel to the upper occludent edge and at the umbo it slightly overhangs the comparatively large, almost circular adductor muscle pit.

DISCUSSION: The broadly angled occludent margin and straight tergal margin at once distinguishes this valve from scuta of *V. gabbi*. Indeed the straight tergal margin distinguishes it from any other known *Virgiscalpellum* scutum; it is preferable for additional material to be examined before reaching a more definite taxonomic opinion.

Virgiscalpellum sp.

(Plate 5, Fig. 13)

MATERIAL: A unique tergum, BMNH In.64477.

LOCALITY: $\frac{1}{2}$ mile E. of State College, probably near Centre W$\frac{1}{2}$ of NW$\frac{1}{4}$ Sec. 6, T.18 N., R.15 E., Oktibbeha County, Mississippi.

HORIZON: upper Ripley Formation, Maastrichtian.

DESCRIPTION: Tergum sub-triangular in outline and about two and a half times as long as wide; it is flat transversely and longitudinally slightly convex. A rounded apico-basal ridge rises from a shallow fold one fourth the length of the valve from the apex; it is bowed towards the carina both at the apex and base. The apex is bluntly rounded and bowed toward the carina. A strong, curved ridge extends from the apex to high on the scutal margin, and a much weaker ridge extends below this to the lower third of the scutal margin. Both ridges are slightly produced at the margin. The occludent margin is convex and bordered by a slightly raised and rounded slip. The scutal angle is acute and sharp. The scutal margin, which is almost twice the length of the occludent, is nearly straight from the scutal angle to the lower ridge, and convex to the base. The carinal margin is concave in its upper half and convex in its lower half. On the outer surface a few longitudinal ridges occur between the lower occludent and the apico-basal ridges. On the inner surface a very narrow ridge curves across the apex and extends down the lower occludent edge.

DISCUSSION: This valve differs from that of *V. gabbi* in its shorter occludent margin and subsequently longer scutal margin, and in its relatively straighter carinal margin. It appears to have no affinities with known South American or European species. With additional material it may prove to be conspecific with the earlier scutum described above.

Sub-order BRACHYLEPADOMORPHA

BRACHYLEPADIDAE Woodward 1901

Genus ***BRACHYLEPAS*** Woodward 1901

1901 *Brachylepas.* Woodward: 150.

DIAGNOSIS: Brachylepadidae with the carina cylindrical or semi-conical and the shell laterally flattened or radially symmetrical; three or four whorls of imbricating plates, the outer whorl of plates with a median basal notch; basis probably membranous or calcareous.

TYPE SPECIES: *B. niassanti* (Hebert).

RANGE: Cretaceous (Turonian to Maastrichtian).

Brachylepas angulosa sp. nov.

(Plate 5, Fig. 16)

MATERIAL: A rostrum, Holotype BMNH. In.64479.

LOCALITY: Barr Pasture, N.W. corner of NE$\frac{1}{4}$ of NW$\frac{1}{4}$ Sec. 6, T.18 N., R.15 E, Oktibbeha County, Mississippi.

HORIZON: Ripley Formation, Maastrichtian.

DESCRIPTION: Rostrum robust and almost as wide as high. A sharp, straight median ridge deflects the sides to about 67° and produces the effect of a hollow pyramid. The apex and basal angles are bluntly rounded. Six prominent flattened ribs extend from the apex to the base (the median ridge is caused by a dominant rib on the left side) and give the base an undulating edge. Very fine ribs are intercalated apically. The growth lines are thin, rounded and somewhat beaded where they are crossed by the secondary ribs. The inner surface is thickened along the inner margins and the growth lines extend downwards from the apex for nearly half the length of the valve. Beneath this on either side four or five shallow fluted depressions extend to the basal margin.

DISCUSSION: The angular nature of the valve is unique among the known species of *Brachylepas*, which have an almost semicircular basal outline. The number of ribs is fewer than that generally encountered in *B. niassanti* and the cancellated ornament of the latter is barely developed in *B. angulosa*. Little more can be said of its affinities with the Western species until further valves become available.

The trivial name refers to the basal outline of the valve.

PART II. GEOLOGY

By F. F. MELLEN

CONTENTS

STRATIGRAPHY

Hitherto, cirripedes from the 'Selma chalk' have all but been ignored stratigraphically in favour of other more easily recognized macroscopic and abundant microscopic index fossils. It was thought that cirripedes might be of biostratigraphical importance from the taxonomic study of the Mississippi/Alabama collections. The horizons of the various species were tabulated and it was seen that they are apparently naturally grouped with no inter-horizon overlapping.

The cirripedes of the 'Selma chalk' may be summarized as follows:

Ripley Formation—Navarroan (Maastrichtian):

C. harnedi, A. bakeri, A. campus, A. withersi, V. g. gabbi, V. g. apertus, B. angulosa.

Basal Annona—Tayloran (Campanian):

C. vallum.

Middle Mooreville—Austinian (Santonian):

C. macrum, C. venustum, A. hubrichti.

The genus *Virgiscalpellum* is restricted to the Ripley and the basal part of the overlying Prairie Bluff. This is overlain almost directly by deposits which contain *Diploschiza melleni*, a small bivalve used as an index fossil in the Prairie Bluff. Two new species of *Arcoscalpellum* and one of *Cretiscalpellum* found with *Virgiscalpellum* also appear to be restricted to this horizon. The Ripley Formation of Oktibbeha County, Miss., seems to be the most prolific cirripede unit yet described from North America. An attempt has been made to zone this unit on the basis of its cirripede fauna, but other than the one specimen of *B. angulosa*, from the mid-Ripley Barr Pasture Locality (M4) there seems to be no significant variation, apart from an apparent increase in abundance of all forms in the middle and upper parts of this unit.

C. vallum appears to have a restricted vertical range. It is found in deposits of outer neritic sediments at the base of the Annona chalk (which is the equivalent of the upper part of the Coffee Sands) some 20–30 ft below the lowest range of *Diploschiza cretacea*, an important zonal indicator.

A. hubrichti and two new species of *Cretiscalpellum* seem to be restricted to a zone which lies near the mid portion of the 250 ft thick Mooreville chalk (marl).

Approximately 250 ft of chalk, and chalky marl separates the zone containing *Virgiscalpellum* from that with *C. vallum*, while about 200 ft of chalky marl separates the zone containing *C. vallum* with that of *A. hubrichti*.

From these observations it is clear that there are three distinct cirripede biostratigraphic 'zones' within the 'Selma'. These, designated in descending order, are:

Zone of *Virgiscalpellum* (Ripley and basal Prairie Bluff—Maastrichtian).

Zone of *Cretiscalpellum vallum* (basal Annona or upper Coffee—Campanian).

Zone of *Arcoscalpellum hubrichti* (middle Mooreville—Santonian).

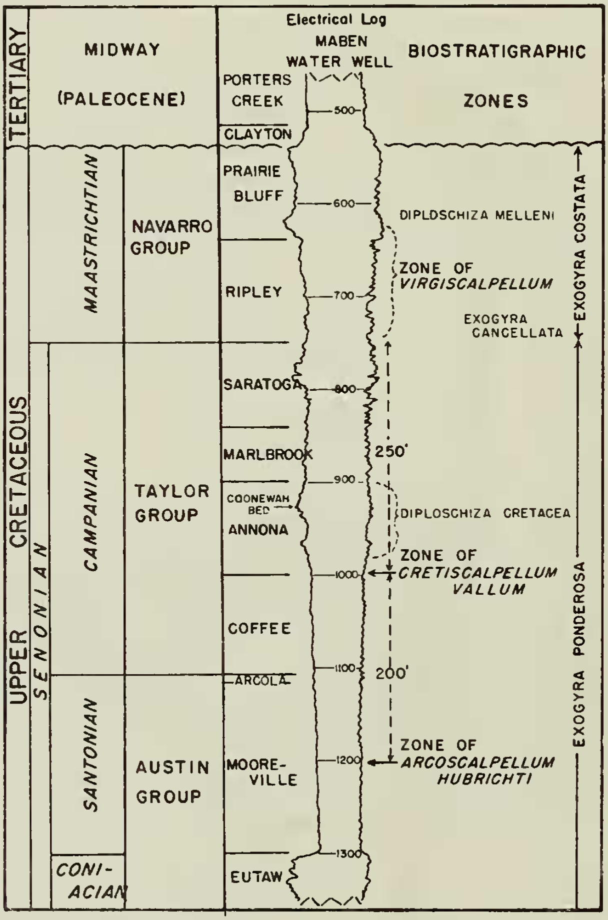

FIG. 4. Correlation and biostratigraphic zones in 'Selma chalk' represented on a selected electrical log, Maben Water Well, SE. ¼ of SW. ¼ of NW. ¼ of Section 31, T. 20 N., R. 12 E., Oktibbeha County, Mississippi. Elevation 466 feet. Position of Zone of *Cretiscalpellum vallum* is interpreted at 1000 feet (—534). This Zone crops out at elevation 200 feet on south valley wall of Tibbee Creek, NE. ¼ of SE. ¼ of Sec. 6, T. 19 N., R. 16 E., Clay County, 24½ miles to the east. The westerly dip of 734 feet is at an average rate of 30 feet per mile, slightly less than the rate of 'true' dip, which is west-southwesterly, about 35 feet per mile.

Geographical range: The zone of *Virgiscalpellum* has been established over an outcrop distance of 155 miles from Coon Creek, McNairy County, Tennessee, to south central Noxubee County, Mississippi. Although most, if not all, of the six species recorded appear possibly to be restricted to this zone, the designation is chosen because *V. gabbi* (Pilsbry) was first reported (by Wade) from the lower Ripley Coon Creek beds of Tennessee; also, this species is the dominant one throughout the Ripley of Oktibbeha County, Mississippi.

The zone of *Cretiscalpellum vallum* has been established over an outcrop distance of 56½ miles from Tibbee Creek, Clay County, Miss., to one mile west of Gainesville, Sumter County, Alabama.

The zone of *Arcoscalpellum hubrichti* has been established at many localities in an outcrop belt about two miles wide in Greene County, Alabama; in 1970, Dr E. E. Russell (Mississippi State University) located the species 4 miles west of Columbus, Lowndes County, Miss. (M12), in the Mooreville, in a position estimated to be 50 ft above its base, thus extending the lateral outcrop over a distance of 65 miles between

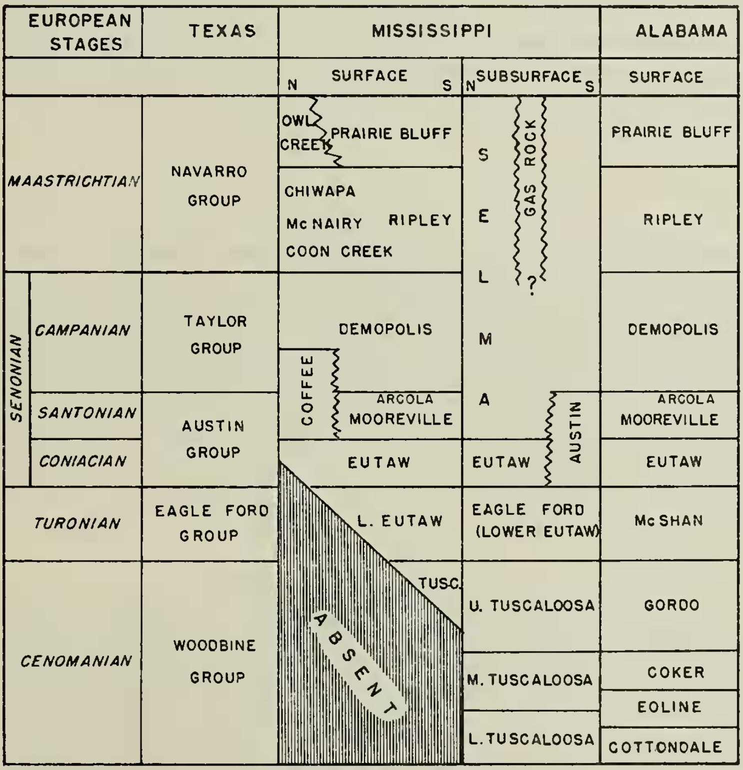

Fig. 5. Correlation chart showing European stages, Texas Group terminology and Upper Cretaceous stratigraphic nomenclature in Mississippi and Alabama. No attempt was made to show range of hiatuses in Texas or Alabama or in the Mississippi subsurface.

the States. Barnacle valves were also found at Cochrane, Pickens County, Alabama, some 15 miles distant from West Green. Recent search has not re-discovered this particular locality, but as Cochrane is on Mooreville terrain, it is probable that the valves recorded were of *A. hubrichti*. Valves of *A. hubrichti* outnumber those of the accompanying species of *Cretiscalpellum* by a ratio of 200 : 1.

A detailed examination of cores and electrical loggings are needed for greater refinement in the stratigraphical placing of the zones of *C. vallum* and *A. hubrichti*.

Cirripedes of the 'Selma chalk' may well be found in sediments of widely varying bathymetric depths, but the present collection seems to have been preserved best in deposits consisting of thin-shelled molluscs, comminuted shell fragments, fine sands and silts. It is suggested that these deposits were formed on outer neritic bottoms of the continental shelf—in depths of 200–600 ft. A notable exception is *V. gabbi* from highly glauconitic and extremely fossiliferous marls of the basal Ripley, Coon Creek beds of McNairy County, Tennessee, which indicates very shallow marine conditions.

The various formations composing the 'Selma chalk' are tabulated for Alabama, Mississippi and Texas, and correlated with the European Stages (Fig. 5). Below the 'Selma' the lower and upper Eutaw are shallow marine and estuarine sediments and would probably yield a cirripede fauna with intensive collecting. Beneath, the sediments of Tuscaloosa Age are almost entirely continental except in the deepest sub-surface.

CRETACEOUS DEPOSITION

All the present cirripede collections were made from deposits on a platform area lying north of a tectonic hinge which marks the northern limit of the Mississippi Interior Salt Basin. The structure of these deposits indicate a massive step by step transgression of the Mesozoic seas from the south. During the late Upper Cretaceous the area of north Mississippi, west Tennessee, west Kentucky, southeast Missouri and northeast Arkansas was covered by marine water for the first time since the retreat of the shallow Upper Carboniferous (Pennsylvanian) seas, Alleghany Revolution (Rodgers, 1967).

The Appalachian Mountain Chain to the north and northeast and the Nashville-Ozark and Ouachita Uplifts to the north and northwest were probably the provenances of the sediments.

The initial dip (Paleoslope) of the strata of 'Selma' age was in a south easterly direction, except in central Alabama and eastwards, although a period of intense volcanism reached its climax during late Taylor or early Navarro times in west-central Mississippi, southeast Arkansas and northeast Louisiana. This produced the highly uplifted and truncated Jackson Dome and the Sharkey-Monroe Uplift from which sediments and igneous detritus have been eroded. Scattered biotite flakes, pyroclastic granules and pebbles, and bentonite deposits in the shallow water Tuscaloosa, Eutaw, Coffee and Ripley Formations which became increasingly abundant near the volcanic uplifts, would seem to be evidence of the importance of contributions of the late Mesozoic volcanism to the geological history of the area.

It is further suggested that the axis of the Mississippi Embayment and its lateral Desha Basin which extends west into southeast Arkansas were a subsidence caused by the initial uplift of the Jackson Dome and the Sharkey-Monroe Uplift to the west.

LOCALITIES AND COLLECTIONS

Mississippi

'Original Collections'

Cirripede valves, from seven localities and totalling 146, were from the Ripley Formation of Oktibbeha County (140) and from the Tayloran chalk of Clay County (6). Of these, 81 were collected by H. H. Harned, Jr., and 65 by Mellen. At the time these collections were made there were no good maps of the area, consequently the collections were designated:

OC.1. 2 miles E. of State College.
(Probably NW¼ of NW¼, Sec. 5, T. 18 N., R. 15 E., Oktibbeha County.)
OC.2. ¾ mile E. of State College (H.H.H., Jr.)
(Probably Bardwell Pasture, S.W. corner NE¼ of NW¼, Sec. 6, T. 18 N., R. 15 E., Oktibbeha County.)
OC.3. ½ mile E. of State College.
(Probably near Centre W½ of NW¼ Sec. 6, T. 18 N., R. 15 E., Oktibbeha County.)
OC.4. Catalpa Creek.
(NW¼ of NE¼ of Sec. 25, T. 18 N., R. 14 E., Oktibbeha County: basal Prairie Bluff.)
OC.5. 5 miles NW. of State College (Stoney Point).
(SW¼ of SW¼ of Sec. 16, T. 19 N., R. 14 E., Oktibbeha County: basal Prairie Bluff and Upper Ripley.)
OC.6. Tibbee Creek (4½ miles S. of West Point).
(NE¼ of SE¼, Sec. 6, T. 19 N., R. 16 E., Clay County: basal Annona or upper Coffee.)
OC.7. 1½ miles E. of State College—Barr Pasture (H.H.H. Jr.)
(Probably N.W. corner of NE¼ of NW¼ of Sec. 6, T. 18 N., R. 15 E., and other outcrops lying to the northwest and northeast.)

Serial numbers have been included to simplify locality recordings in the text.

Other collections made by Harned during the 1930's were included in material sent directly to Collins later, are marked 'Barr and Bardwell Pastures', 'Barr', and 'Sand Creek and Barr'. It would be imprecise to attempt to assign more specific location descriptions to the old collections due to the fact that some of the old chalk gullies have been completely filled and obliterated in recent years.

Mississippi

'Recent Collections'

M1. 'Oktibbeha County, from Dunn Seiler Museum'—exact localities unknown, but all undoubtedly from the Ripley of the MSU campus area.
M2. Barr & Bardwell Pastures: NE¼ of NW¼ Sec. 6, T. 18 N., R. 15 E., Oktibbeha County (H. H. Harned, Jr., Coll.) (middle Ripley).
M3. Barr Pasture: N.W. Corner of NE¼ of NW¼ of Sec. 6, T. 18 N., R. 15 E., Oktibbeha County (H. H. Harned, Jr. Coll.) (middle Ripley).
M4. Barr Pasture: cf. 'M3'. (middle Ripley)
M5. Bardwell Pasture: S.W. Corner of NE¼ of NW¼ of Sec. 6, T. 18 N., R. 15 E., Oktibbeha County (H. H. Harned, Jr. Coll.). These gullies have been filled and completely obliterated. (middle Ripley)

M6. Sand Creek & Barr: Probably SW$\frac{1}{4}$ Sec. 31, T. 19 N., R. 15 E. & N.W. Corner of NE$\frac{1}{4}$ of NW$\frac{1}{4}$ Sec. 6, T. 18 N., R. 15 E. Oktibbeha County (H. H. Harned, Jr. Coll.). (middle & lower Ripley)
M7. 6 Miles N.W. of Starkville (H. H. Harned, Jr. Coll.) Locality indeterminable, but probably upper Ripley.
M8. N. of Evans Hall: NW$\frac{1}{4}$ of NW$\frac{1}{4}$ Sec. 1, T. 18 N., R. 14 E., Oktibbeha County.
M9. Chapel Hill Church locality of S. valley wall Catalpa Creek, 5 miles S. & 1·75 miles E. of Barr Pasture locality, NE$\frac{1}{4}$ of NE$\frac{1}{4}$ Sec. 32, T. 18 N., R. 15 E., Oktibbeha County.
M10. Trim Cane—Josey Creeks confluence; SW$\frac{1}{4}$ of SW$\frac{1}{4}$ Sec. 20, T. 19 N., R. 14 E., Oktibbeha County.
M11. 4$\frac{1}{2}$ miles S. of West Point, S. valley wall of Tibbee Creek, E. of U.S. Highway, 45—W.: NE$\frac{1}{4}$ of SE$\frac{1}{4}$ Sec. 6, T. 19 N., R. 16 E., Clay County. (basal Annona or upper Coffee.)
M12. Cuts in Highway 82 bypass, c. 4 miles W. of Columbus, Secs. 26 & 27, T. 19 N., R. 17 E. Lowndes County.

Alabama

A1. Approx. S.W. corner SE$\frac{1}{4}$ of NE$\frac{1}{4}$ Sec. 27, T. 23 N., R. 1 W., on public road (through W. M. Steele land), 1$\frac{1}{2}$ miles N. of West Greene, Greene County.
A2. c. 1 mile N.E. of 'A1', c. SW$\frac{1}{4}$ of SE$\frac{1}{4}$, Sec. 23, T. 23 N., R. 1 W., Greene County.
A3. c. 1$\frac{1}{2}$ miles N.W. of 'A1', near centre NW$\frac{1}{4}$ Sec. 22, T. 23 N., R. 1 W., Greene County.
A4. 2 miles E. of West Greene, 4 miles N. of Clinton, near Centre SW$\frac{1}{4}$ Sec. 36, T. 23 N., R. 1 W., Greene County.
A5. 3 miles E. of West Greene & 3 miles W. of Clinton, c. $\frac{1}{4}$ miles N.E. of church, c. Centre SW$\frac{1}{4}$ Sec. 31, T. 23 N., R. 1 E. Greene County.
A6. Mt. Olive Church, around the common quarter corner, Secs. 30 & 31, T. 22 N., R. 1 E., Greene County.
A7. 1·2 miles due E. of Mt. Olive Church and in SW$\frac{1}{4}$ of SW$\frac{1}{4}$ Sec. 32, T. 22 N., R. 1 E., Greene County.
A8. 1 mile S.E. of Mt. Olive Church locality; 1$\frac{1}{2}$ miles N.E. of Mt. Olive Church, north of Highway, Greene County.
A9. Shallow washes in brushy area W. of paved road 4$\frac{1}{2}$ miles S.S.W. of Eutaw in SW$\frac{1}{4}$ of NE$\frac{1}{4}$ of Sec. 20, T. 21, N., R. 2 E., Greene County.
A10. 1 mile W. of Gainesville, NE$\frac{1}{4}$? Sec. 10, T. 21 N., R. 2 W. Sumter County.
A11. 'Bonanza', SW$\frac{1}{4}$ of SW$\frac{1}{4}$, Sec. 32, T. 22 N., R. 1 E., Greene County.

ACKNOWLEDGEMENTS

The writers are greatly obligated to many people for assistance in the collecting, preservation and study of the cirripedes covered in the present work: to Professors Troy J. Laswell, Ernest E. Russell and Donald M. Keady of the Department of Geology and Geography at Mississippi State University for assistance in collecting and encouragement of student participation, and for affording a repository for barnacle collections and literature in the Dunn-Seiler Geology Museum; to Andrew Martin, Terry Christian, William Honey and John Kline for contributed specimens; to Stephen Hook who collected with one of us (F.F.M.) and made numerous other contributions during 1968; to Horace H. Harned, Jr., and Wentworth V. Harned, who, as students of geology at Mississippi State University, collected and supplied considerable material from the Ripley of Oktibbeha County: to

Leslie Hubricht, of Meridian, Miss., collector of the type material of *Arcoscalpellum hubrichti* and to Dr K. V. W. Palmer for kindly allowing access to this material; to the Keeper of Palaeontology, British Museum (Natural History), for making available Withers' notes and the original material; to Dr W. T. Dean, R. Baker (retired), S. F. Morris and W. R. Smith, also of the British Museum (Natural History) for kindly allowing access to specimens in their charge, and to C. W. Wright, of London, for allowing us to examine specimens in his collection and for much valuable advice.

We wish to record our warmest thanks also to Dr James W. Ward of the Anatomy Department of the University of Mississippi School of Medicine and Drs Gordon Gunter and J. Y. Christmas of Gulf Coast Research Laboratory, who furnished specimens of recent cirripedes and expressed much interest in this work; to Dr Wayne E. Moore, Division Paleontologist of Chevron Oil Company, for his critical review of the geological parts of this paper; to the Photographic Department, British Museum (Natural History) and to E. Kentish, of London, who prepared the photographs.

Support for extensive field work and other geological studies by Mellen has been afforded by Germany-Gulmon Oil Company; the Mississippi Geological Survey; and by the Mississippi Research and Development Center under its Grant Number 1–68–70. Also, many palaeontologists and stratigraphers were of assistance and encouragement during the investigation.

REFERENCES

ADKINS, W. S. 1928. Handbook of Texas Cretaceous Fossils. *Univ. Texas Bull.* **2838,** 1–304, pls., 1–37.

BRAUNSTEIN, J. 1950, 1959. Subsurface Stratigraphy of the Upper Cretaceous in Mississippi. In *Cretaceous of Mississippi and South Tennessee*: Eighth Field Trip Guidebook, Mississippi Geol. Soc.; In *Upper Cretaceous Outcrops Northeast Mississippi and West Central Alabama*: Fourteenth Field Trip Guidebook, Mississippi Geol. Soc., Jackson.

CAPLAN, W. M. 1954. Subsurface Geology and Oil and Gas Possibilities of Northwestern Arkansas; *Bull. geol. Surv. Ark.*, Little Rock, **20.**

CHEETHAM, A. H. 1963. Gooseneck Barnacles in the Gulf Coast Tertiary. *J. Paleont.*, Tulsa, Oklahoma, **37** : 393–400, pl. 46.

COLLINS, J. S. H. 1965. *Arcoscalpellum comptum* (Withers), a cirripede new to the Gault. *Palaeontology*, Lond., **8** : 629–633, pl. 90.

DARWIN, C. R. 1851. A Monograph on the Fossil Lepadidae, or Pedunculated Cirripedes of Great Britain. vi–88 pp., 5 pls., *Palaeontogr. Soc. Monogr.*, London.

FISK, H. N. 1944. *Geological Investigation of the Alluvial Valley of the Lower Mississippi River.* Mississippi River Comm.

GROHSKOPF, J. G. 1955. *Subsurface Geology of the Mississippi Embayment of Southeast Missouri*: *Rep. Mo. geol. Surv. Wat. Res.*, Rolla, **37,** Sec. Ser.

HOEK, P. P. C. 1907. The Cirripedia of the Siboga Expedition: Siboga Exped. Rept., 31A, Cirripedia Pedunculata, 127 pp., 10 pls.

MELLEN, F. F. 1958. Cretaceous Shelf Sediments of Mississippi, *Bull. Miss. geol. Surv.*, Mississippi, **85.**

MONROE, W. H. 1941. Notes on Deposits of Selma and Tipley Age in Alabama. *Bull. geol. Surv. Ala.*, Montgomery, **78.**

Pilsbry, H. A. 1916. The Sessile Barnacles (Cirripedia) contained in the Collection of the U.S. National Museum; including a Monograph of the American Species. *Bull. U.S. nat. Mus.*, Washington, **93** : xii—366 pp., 76 pls., 99 text figs.

—— 1933. An unusual Cretaceous Cirriped. *Science*, **77** : 1994, 283–284.

Pilsbry, H. A. & Olssen, A. A. 1951. Tertiary and Cretaceous Cirripedia from Northwestern South America. *Proc. Acad nat. Sci. Philad.*, **103** : 197–210, pls. 6–11.

Pryor, W. A. 1960. Cretaceous Sedimentation in Upper Mississippi Embayment. *Bull. Am. Ass. Petrol. Geol.*, Chicago **44** : 9.

Rainwater, E. H. 1963. Geological History and Oil and Gas Possibilities of Mississippi; In Mississippi Geologic Research Papers—1962, *Bull. Miss. geol. Surv.*, **97.**

Richards, H. G. 1958. The Cretaceous Fossils of New Jersey. Bur. Geol. and Topogr., Trenton, N.J., Pt. 1., vi–266, 46 pls.

Rodgers, J. 1967. Chronology of Tectonic movements in the Appalachian Region of Eastern North America, in *Symposium on the Chronology of Tectonic movements in the United States. Amer. Jour. Sci.*, New Haven, **265,** no. 5, pp. 408–27, table.

Russell, L. S. 1967. A Pedunculate Cirripede from Upper Cretaceous Rocks of Saskatchewan. *J. Paleont.*, Tulsa, Oklahoma, **41** : 1544–1547, 5 text figs.

Shumard, B. F. 1862. Descriptions of new Cretaceous fossils from Texas. *Proc. Boston Soc. Nat. Hist.*, **8** : 188–205.

Stephenson, L. W. & Monroe, W. H. 1940. The Upper Cretaceous Deposits (of Mississippi). *Bull. Miss. geol. Surv.*, **40.**

Stephenson, *et al.* 1942. Cretaceous Correlation. *Bull. geol. Soc. Amer.*, New York **53** : 435–448.

Wade, B. 1926. The fauna of the Ripley Formation on Coon Creek, Tennessee. *U.S. Geol. Surv., Prof. Paper*, **137**, 1–272, 62 pls.

Withers, T. H. 1928–1953. *Catalogue of Fossil Cirripedia in the Department of Geology, British Museum (Natural History)* : 1928 *Triassic and Jurassic.* xii–154, 12 pls.; 1935 *Cretaceous.* xvi–434, 50 pls.; 1953 *Tertiary.* xv–396, 64 pls. London, British Museum (Natural History).

—— 1945. New Cretaceous Cirripedes and Crab. *Ann. Mag. nat. Hist., London*, Ser. 2, **5** : 552–561, pl. 2.

J. S. H. Collins
63, Oakhurst Grove
E. Dulwich
London, S.E.22.

Frederic F. Mellen
1202 Standard Life Building
Jackson
Mississippi 39201
U.S.A.